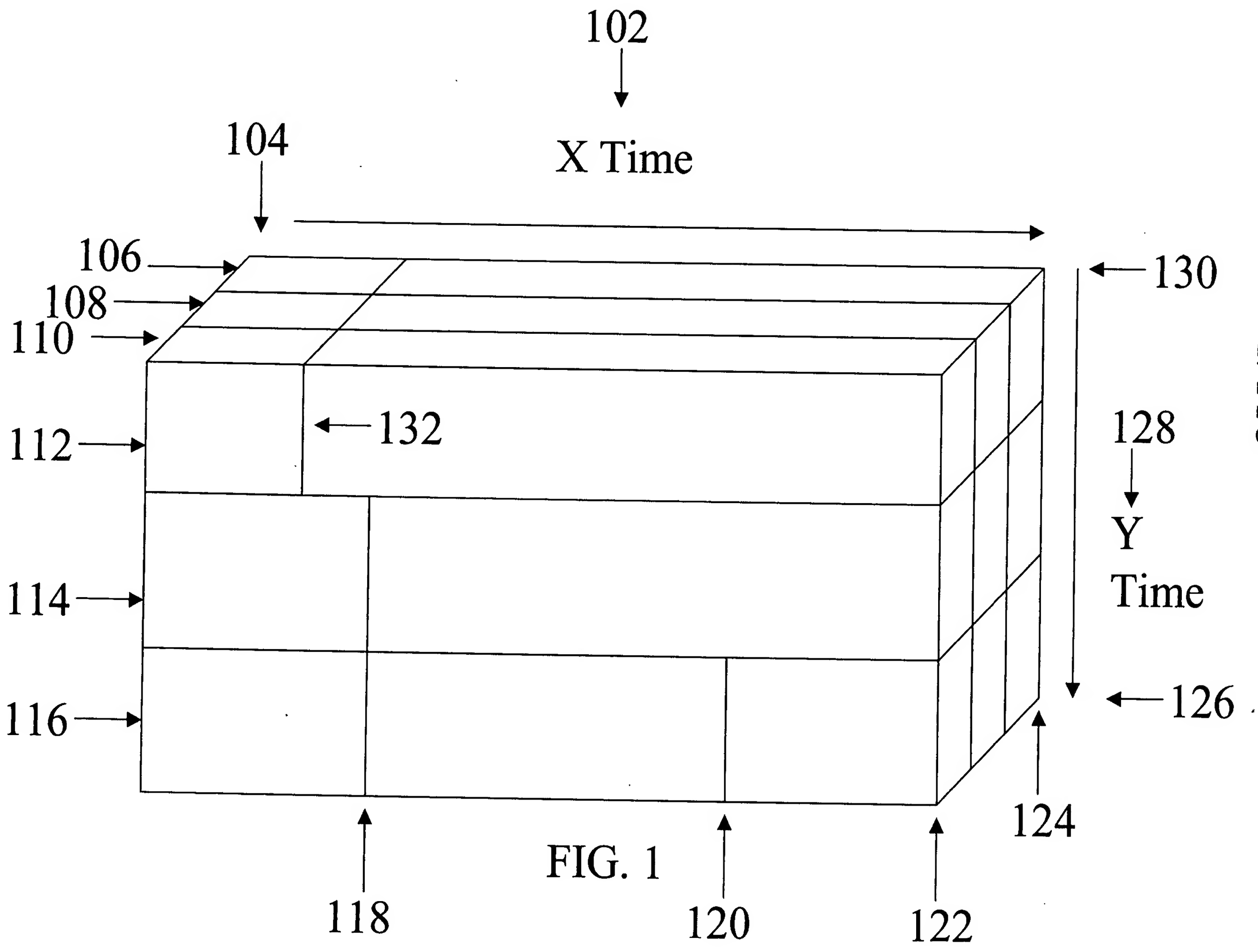
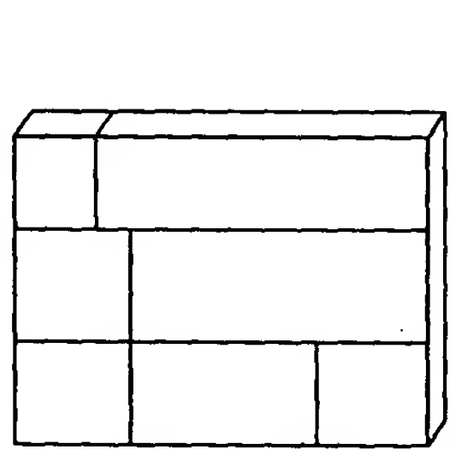
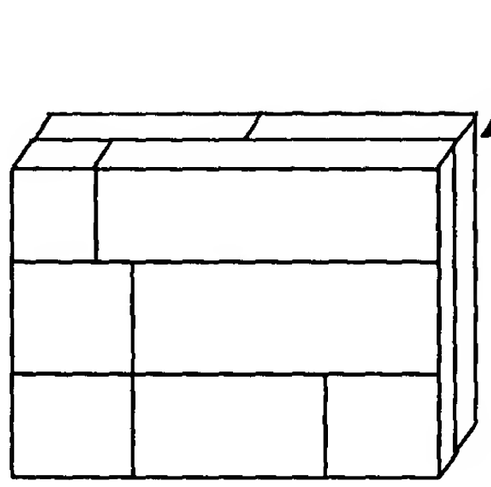
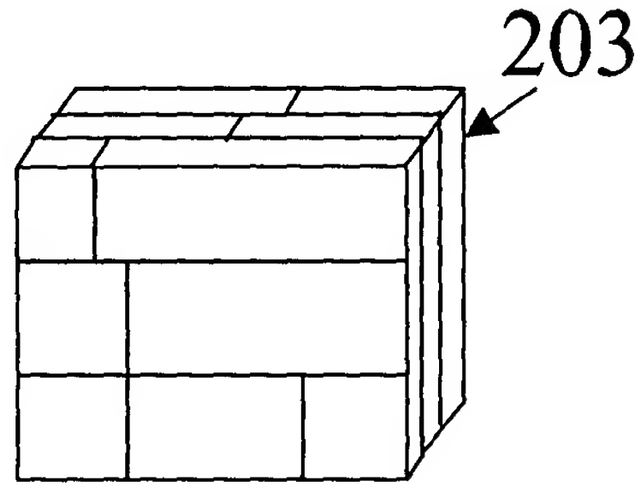
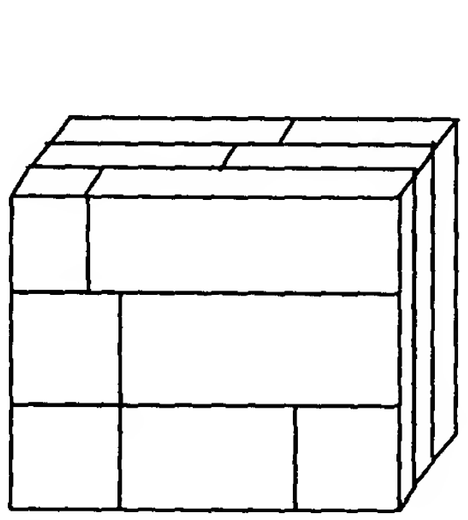

102
X Time
104
106
108
110
112
114
116
130
132
128
Y
Time
126
124
118
120
122

FIG. 1

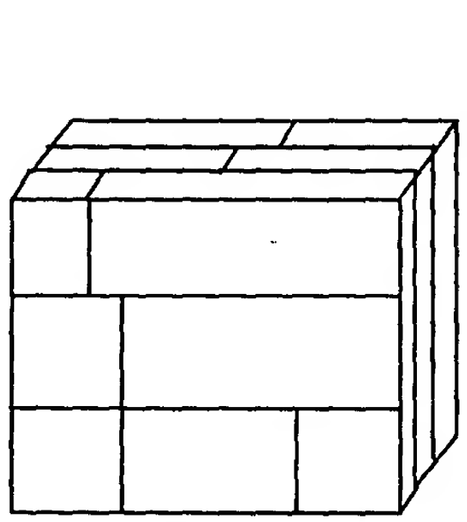




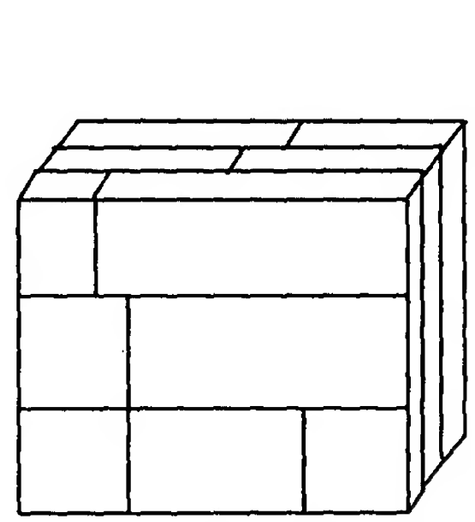




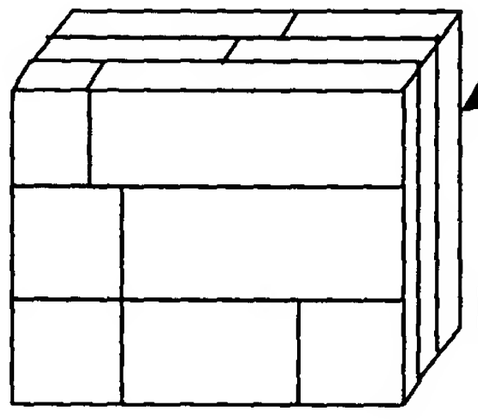
by(tuple group)



by(tuple group)by(entity)



by(tuple group)by(entity)by(entity group)



by(tuple group)by(entity)by(entity group)by(system)

FIG. 2

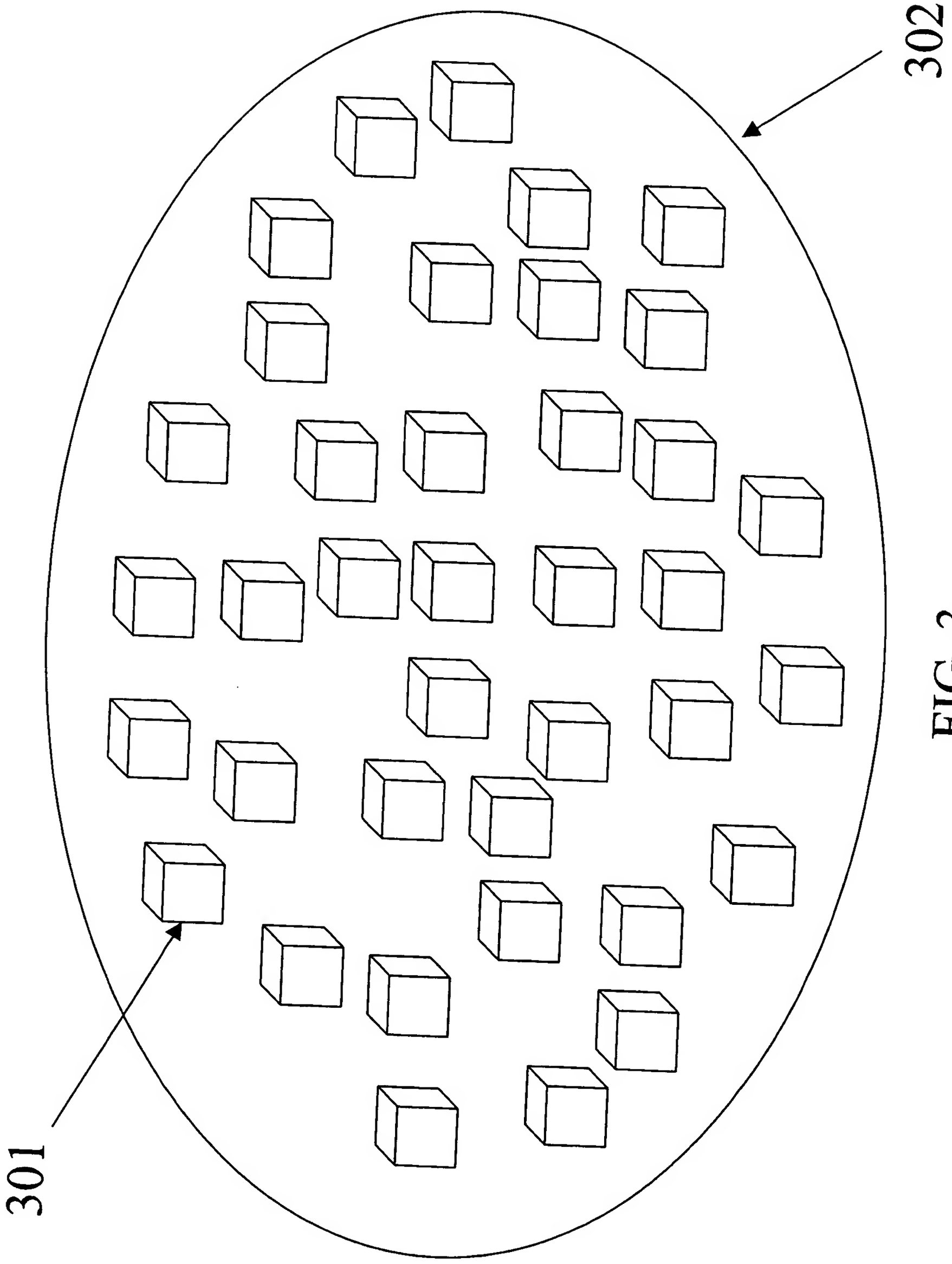


FIG. 3

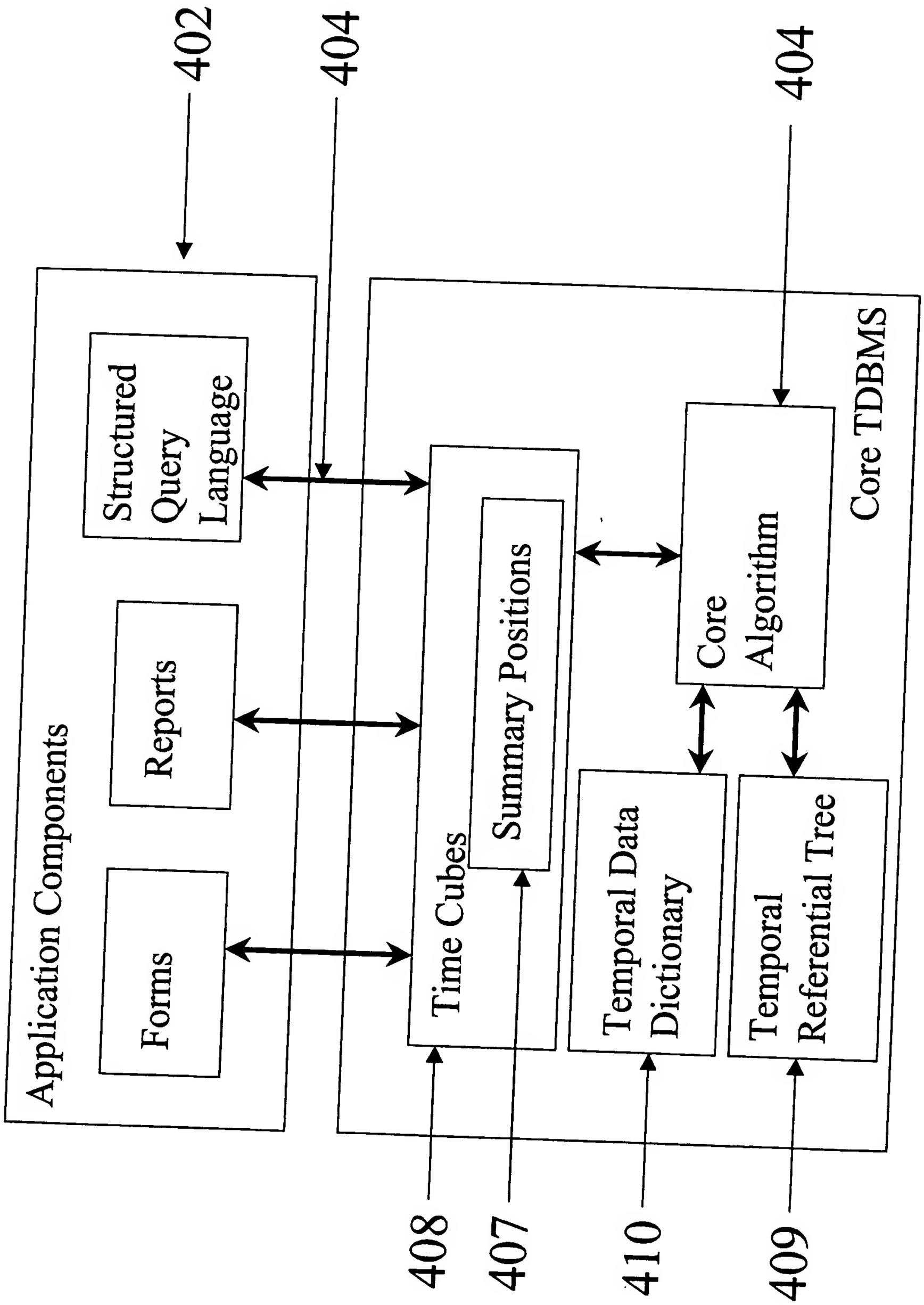

402
404
404
Application Components
Forms
Reports
Structured Query Language
Core TDBMS
Core Algorithm
Summary Positions
Time Cube
Temporal Data Dictionary
Temporal Referential Tree
408
407
410
409

FIG. 4

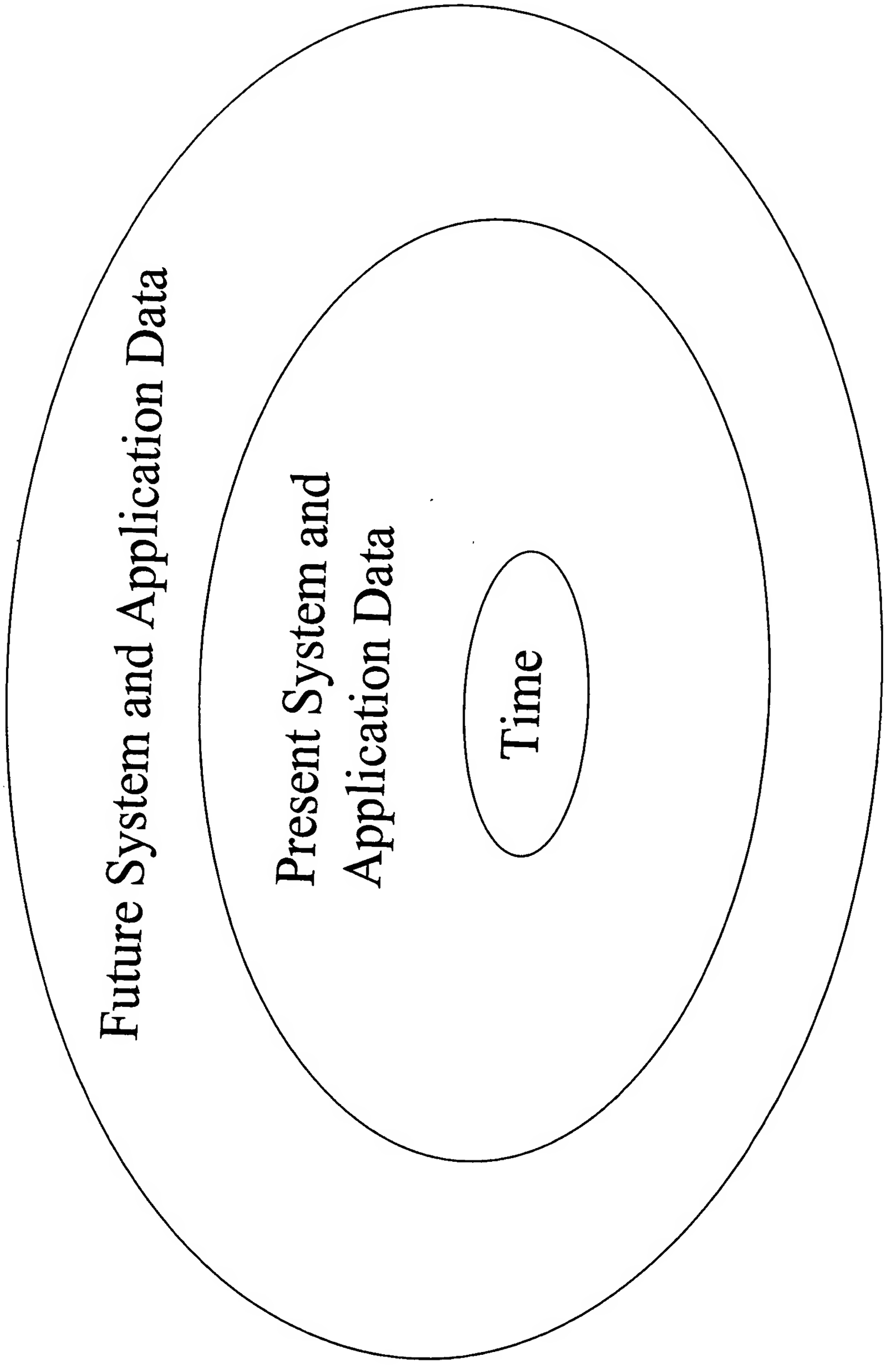

Future System and Application Data
Present System and Application Data
Time

FIG. 5

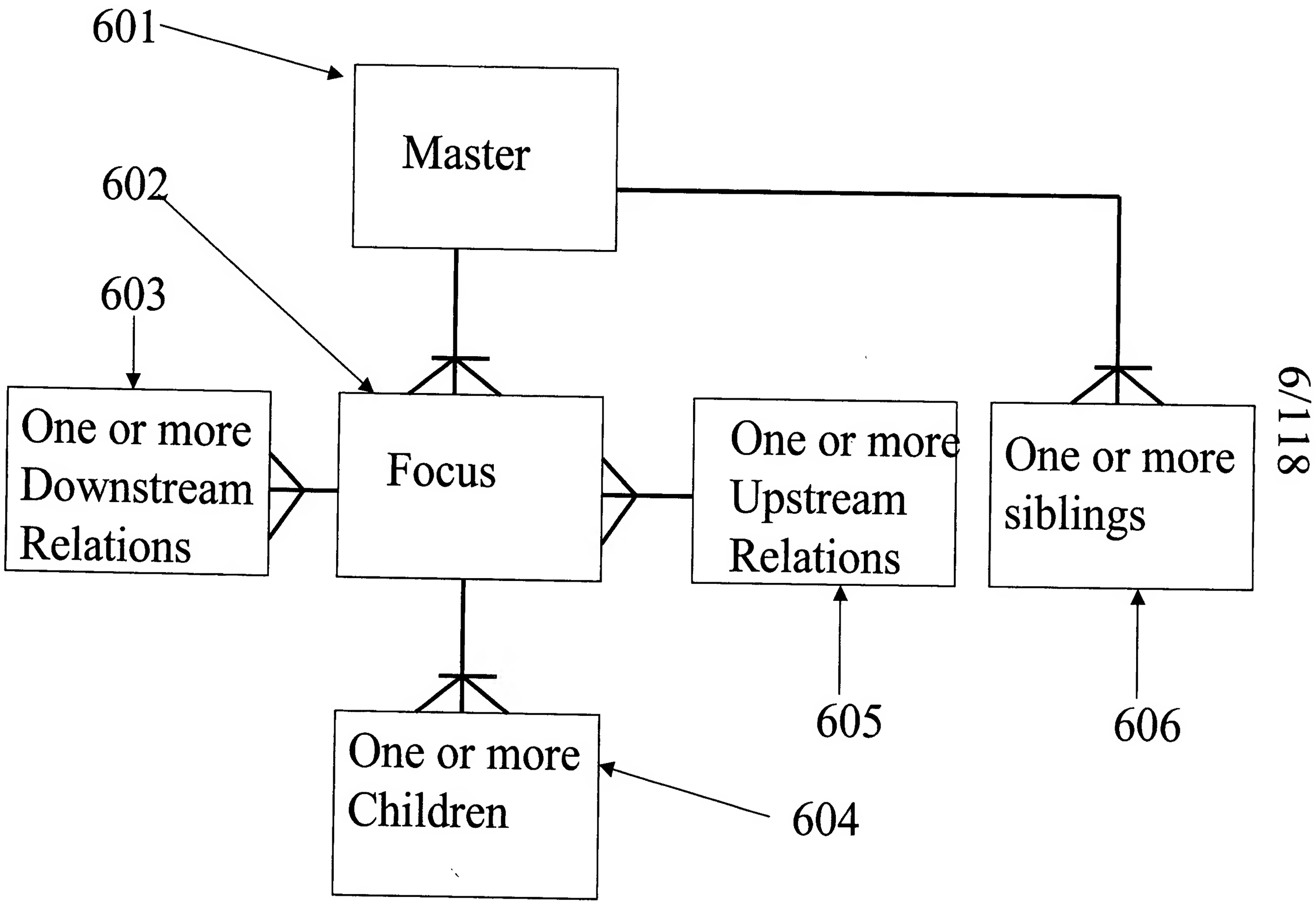
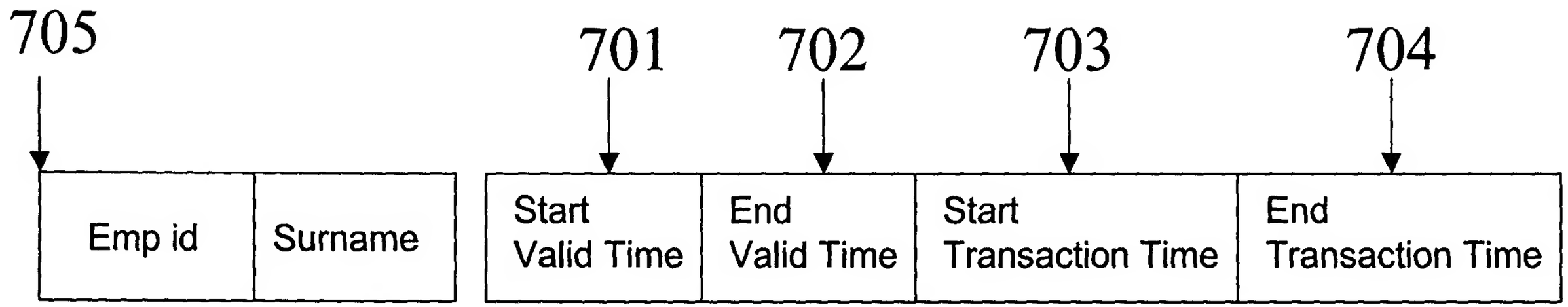

601
Master
602
603
One or more Downstream Relations
Focus
One or more Upstream Relations
One or more siblings
One or more Children
604
605
606

FIG. 6


705
701
702
703
704
Emp id
Surname
Start Valid Time
End Valid Time
Start Transaction Time
End Transaction Time

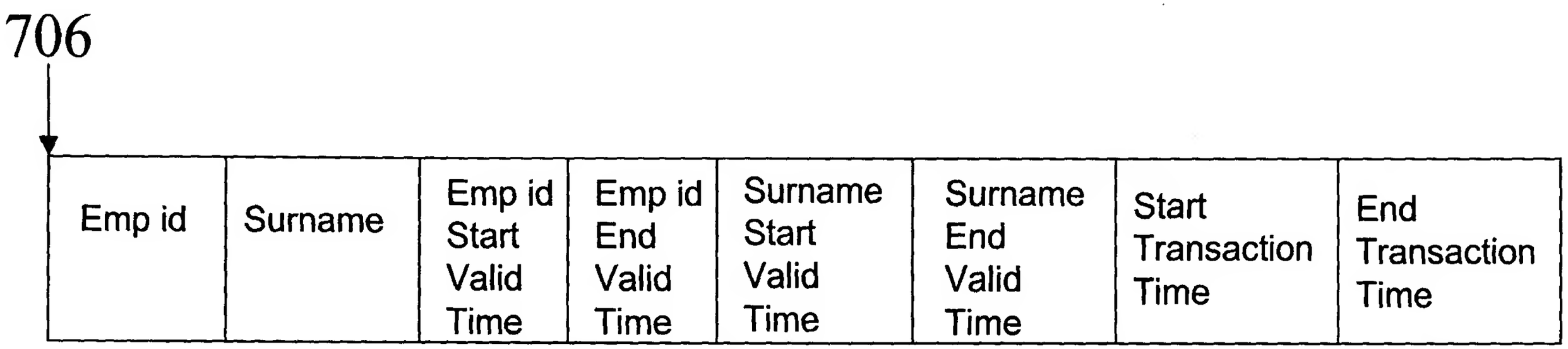

706
Emp id
Surname
Emp id Start Valid Time
Emp id End Valid Time
Surname Start Valid Time
Surname End Valid Time
Start Transaction Time
End Transaction Time

FIG. 7a

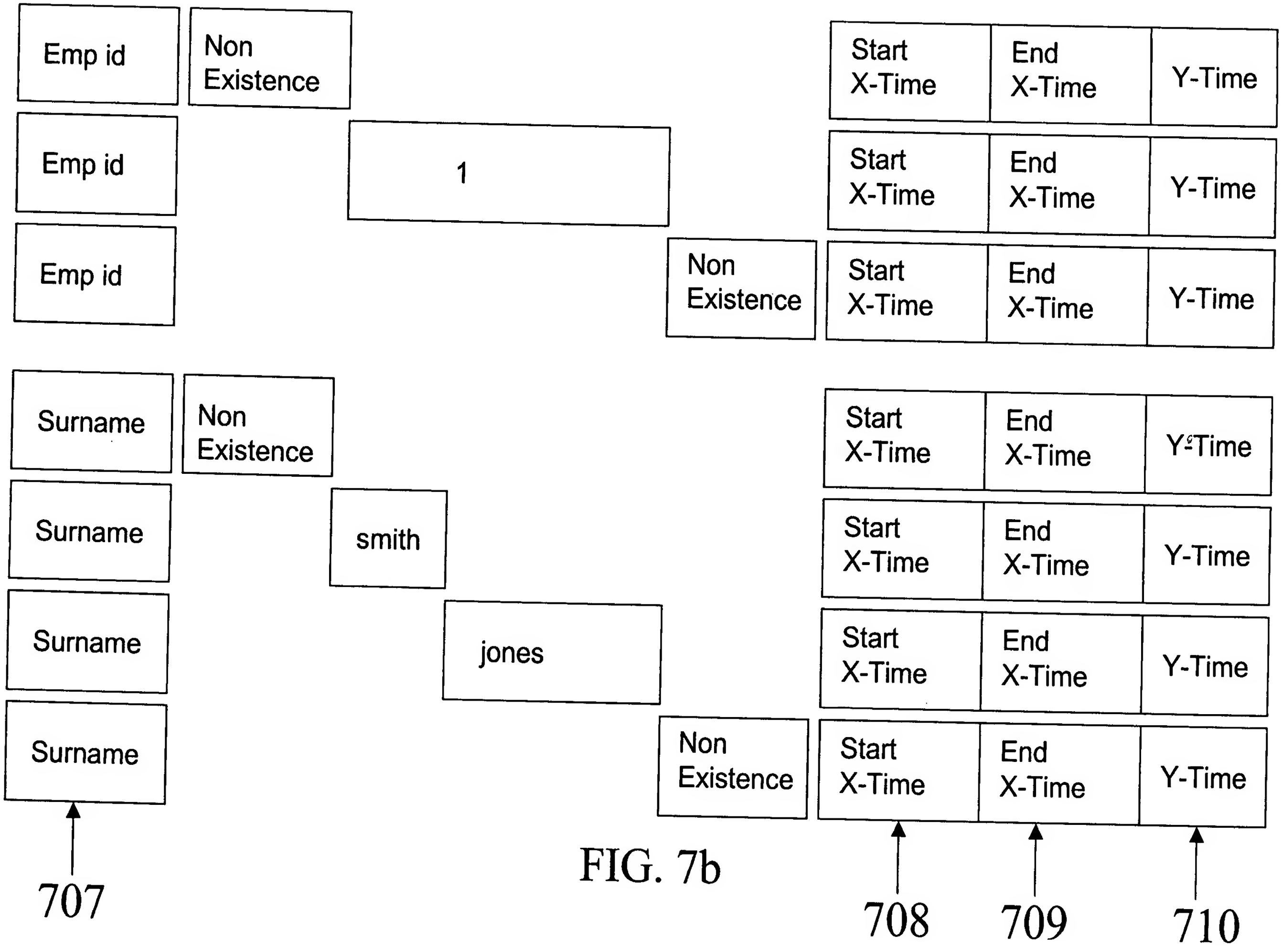

Emp id
Non Existence
Emp id
1
Emp id
Non Existence
Start X-Time
End X-Time
Y-Time
Start X-Time
End X-Time
Y-Time
Start X-Time
End X-Time
Y-Time
Surname
Non Existence
Surname
smith
Surname
jones
Surname
Non Existence
Start X-Time
End X-Time
Y-Time
Start X-Time
End X-Time
Y-Time
Start X-Time
End X-Time
Y-Time
Start X-Time
End X-Time
Y-Time
707
708
709
710

FIG. 7b

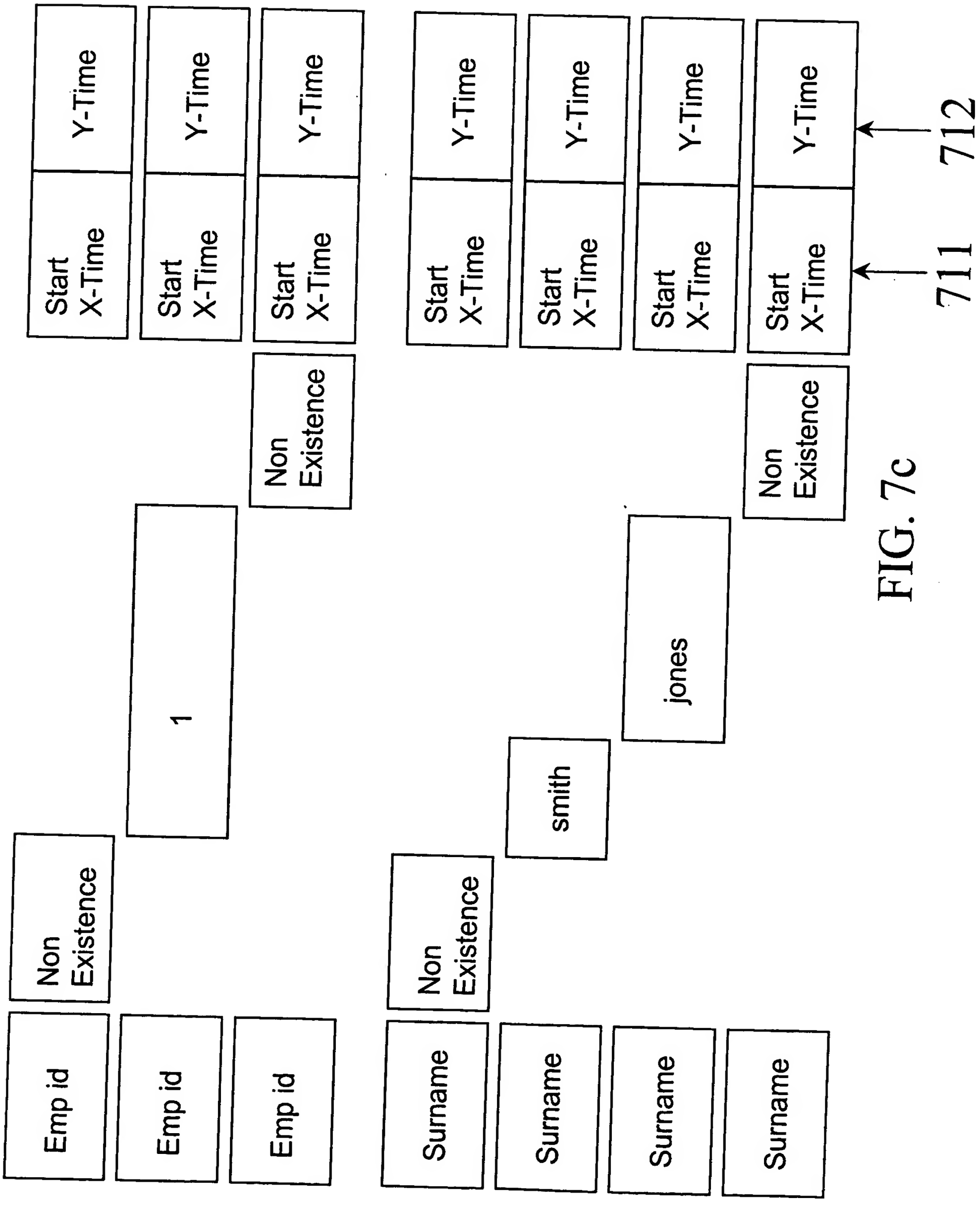

Emp id
Surname
Non Existence
1
jones
Emp id
Surname
Non Existence
smith
Emp id
Surname
Start X-Time
Non Existence
Emp id
Surname
Start X-Time
Non Existence
Emp id
Surname
Start X-Time
Non Existence
Emp id
Surname
Start X-Time
Non Existence
Y-Time
Start X-Time
Y-Time
Start X-Time
Y-Time
Start X-Time
Y-Time
Start X-Time
Y-Time
712
711

FIG. 7c

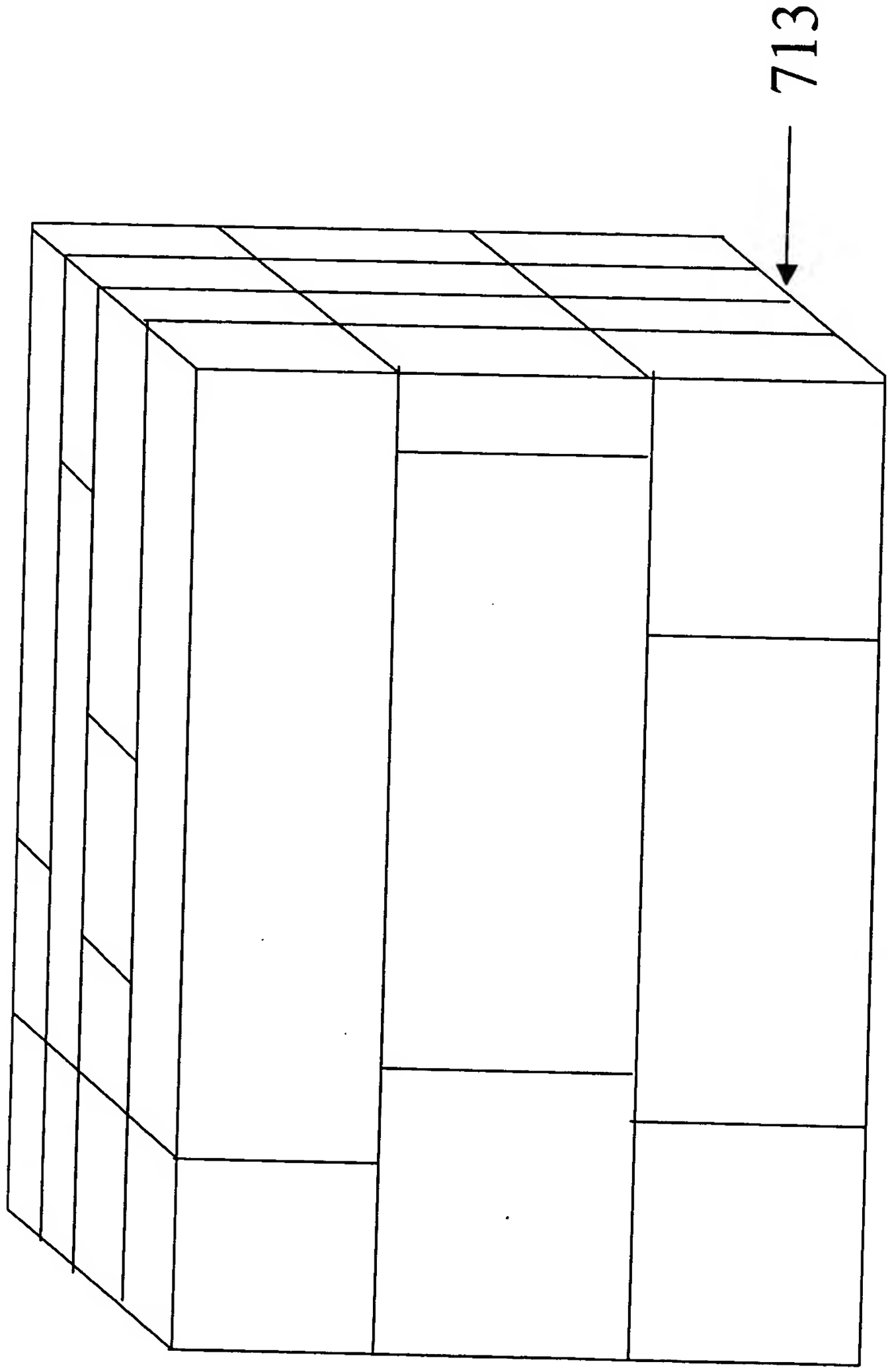


FIG. 7d

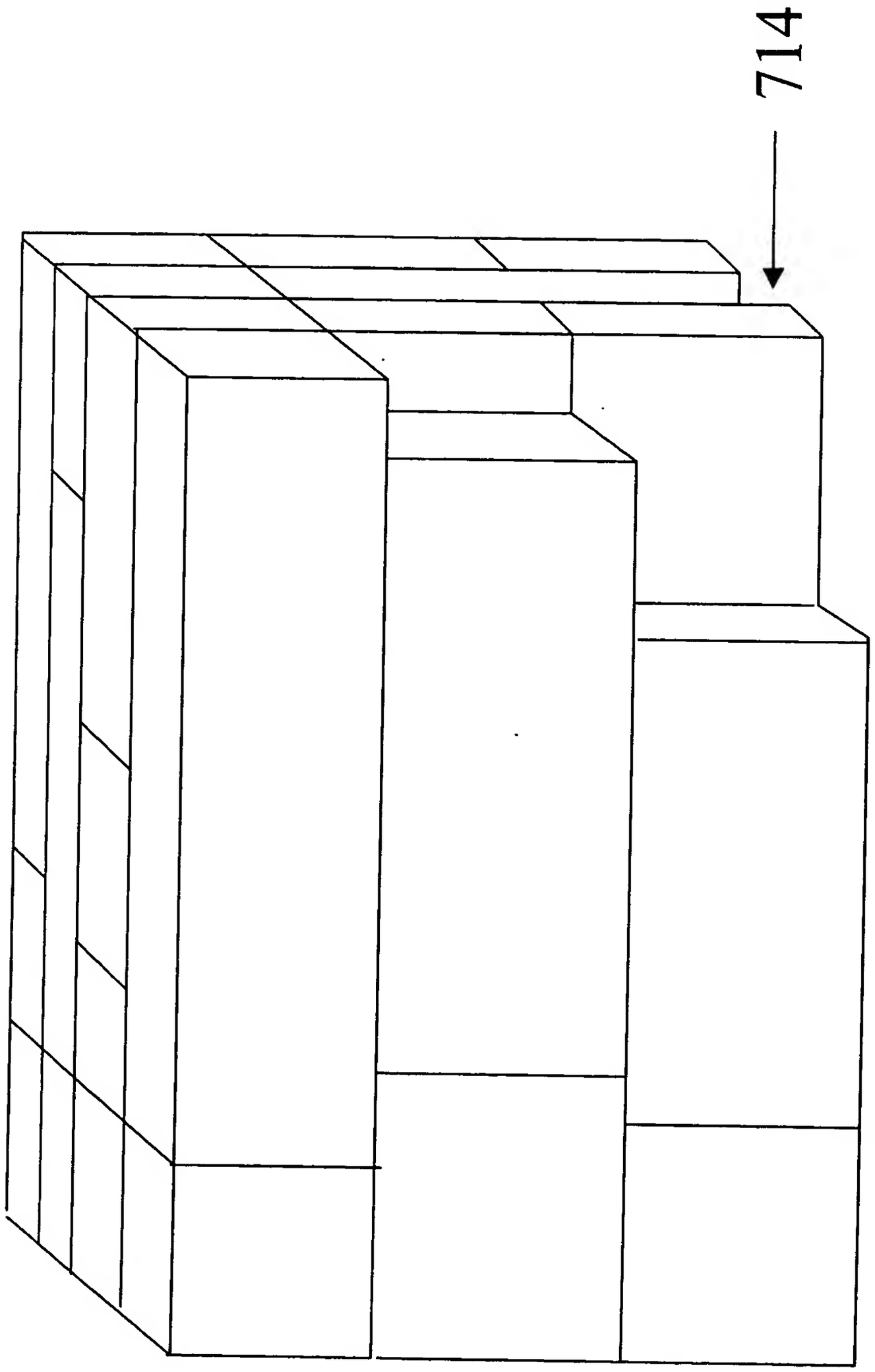


FIG. 7e

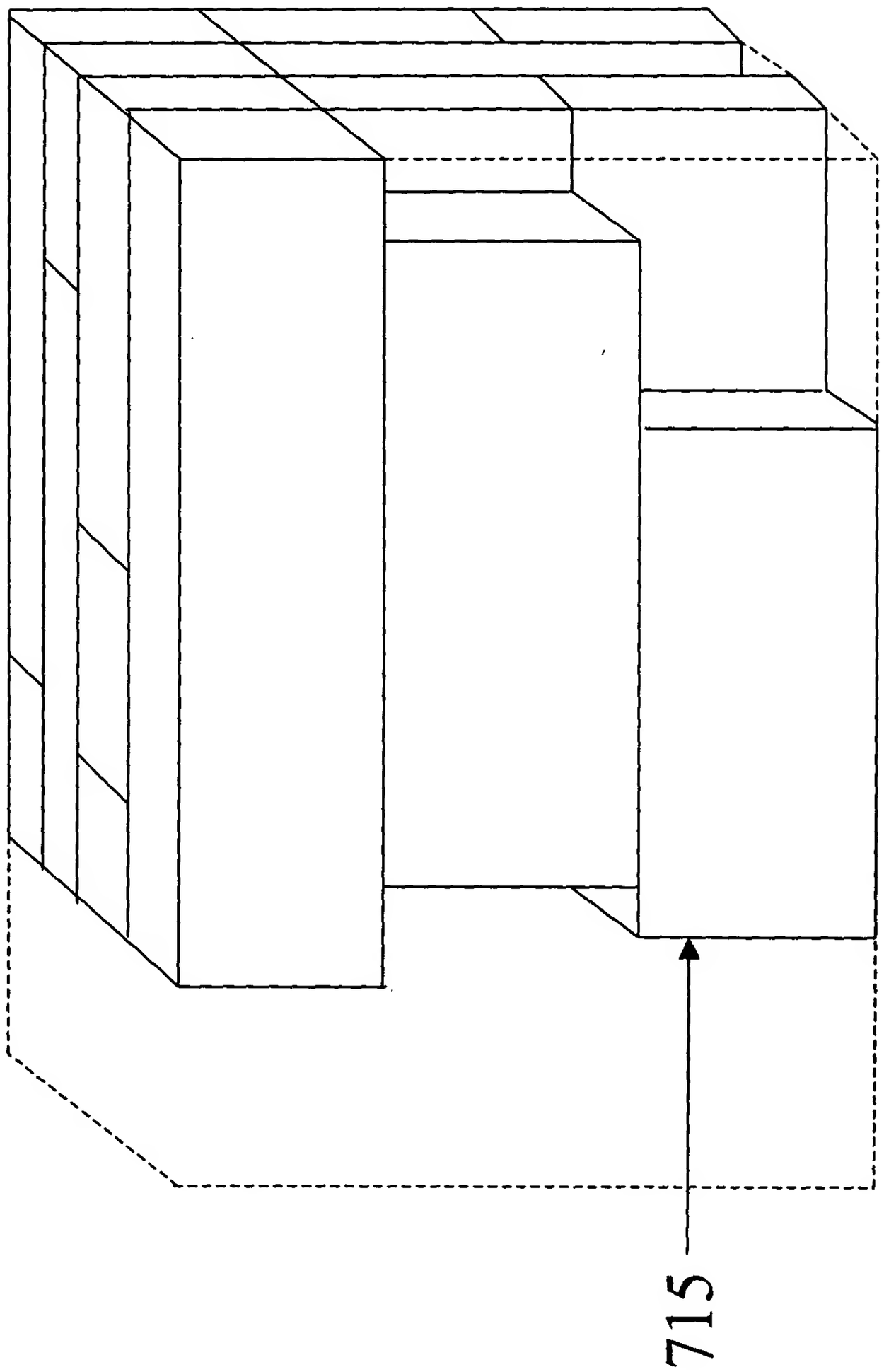


FIG. 7f

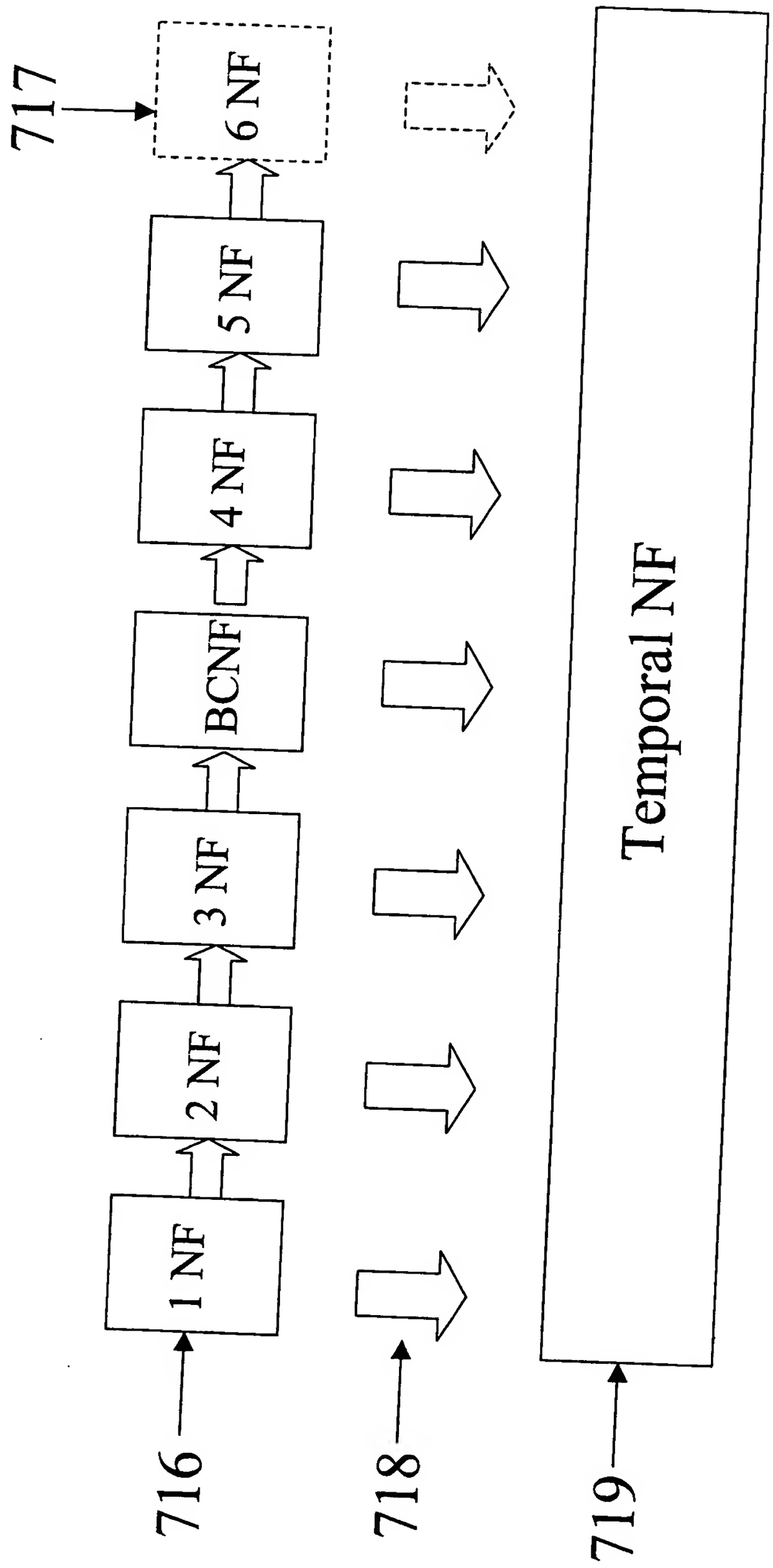


FIG. 7g

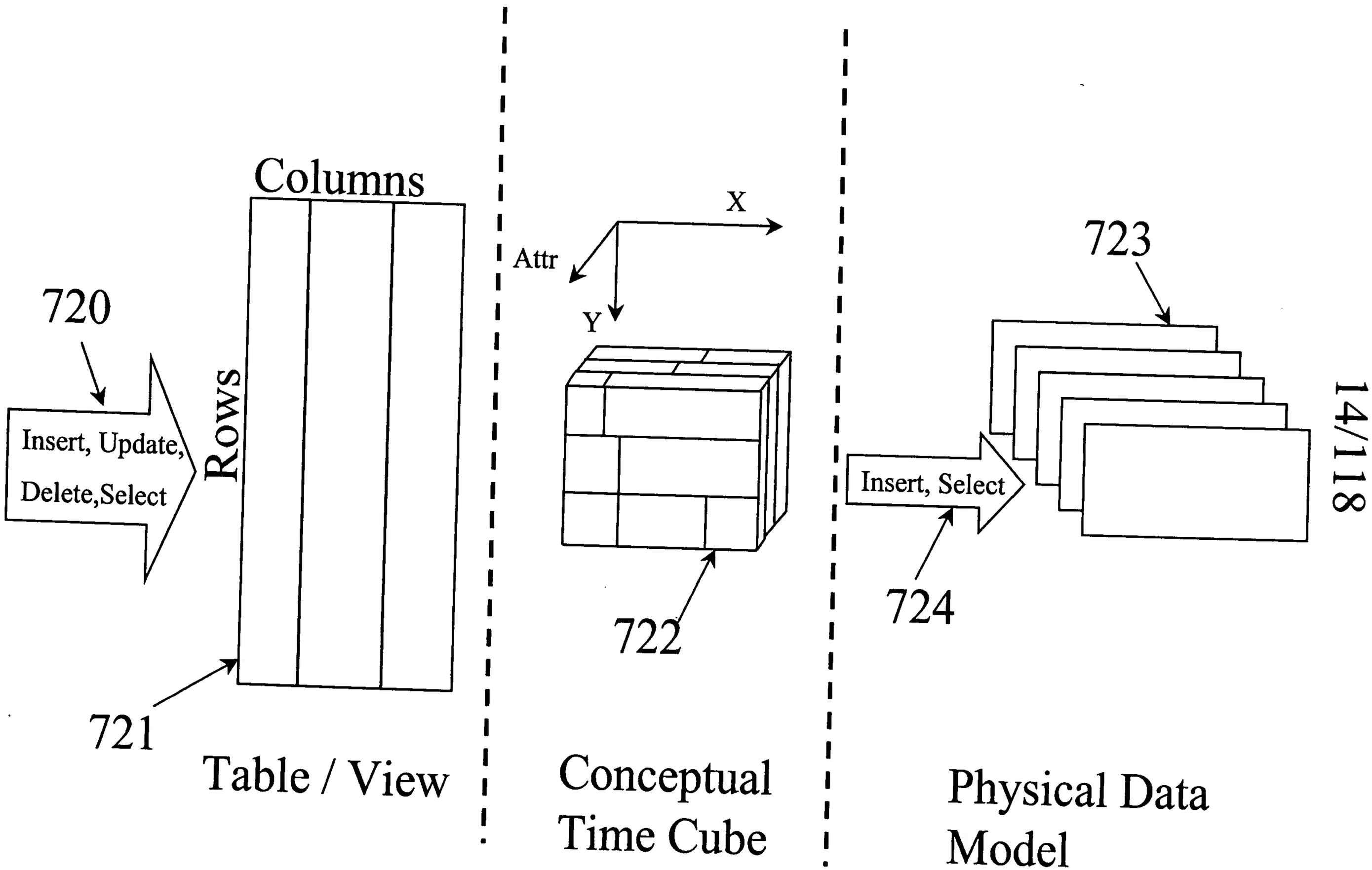

Columns
Rows
720
Insert, Update,
Delete,Select
721
Table / View
X
Attr
Y
722
Conceptual
Time Cube
723
Insert, Select
724
Physical Data
Model

FIG. 7h

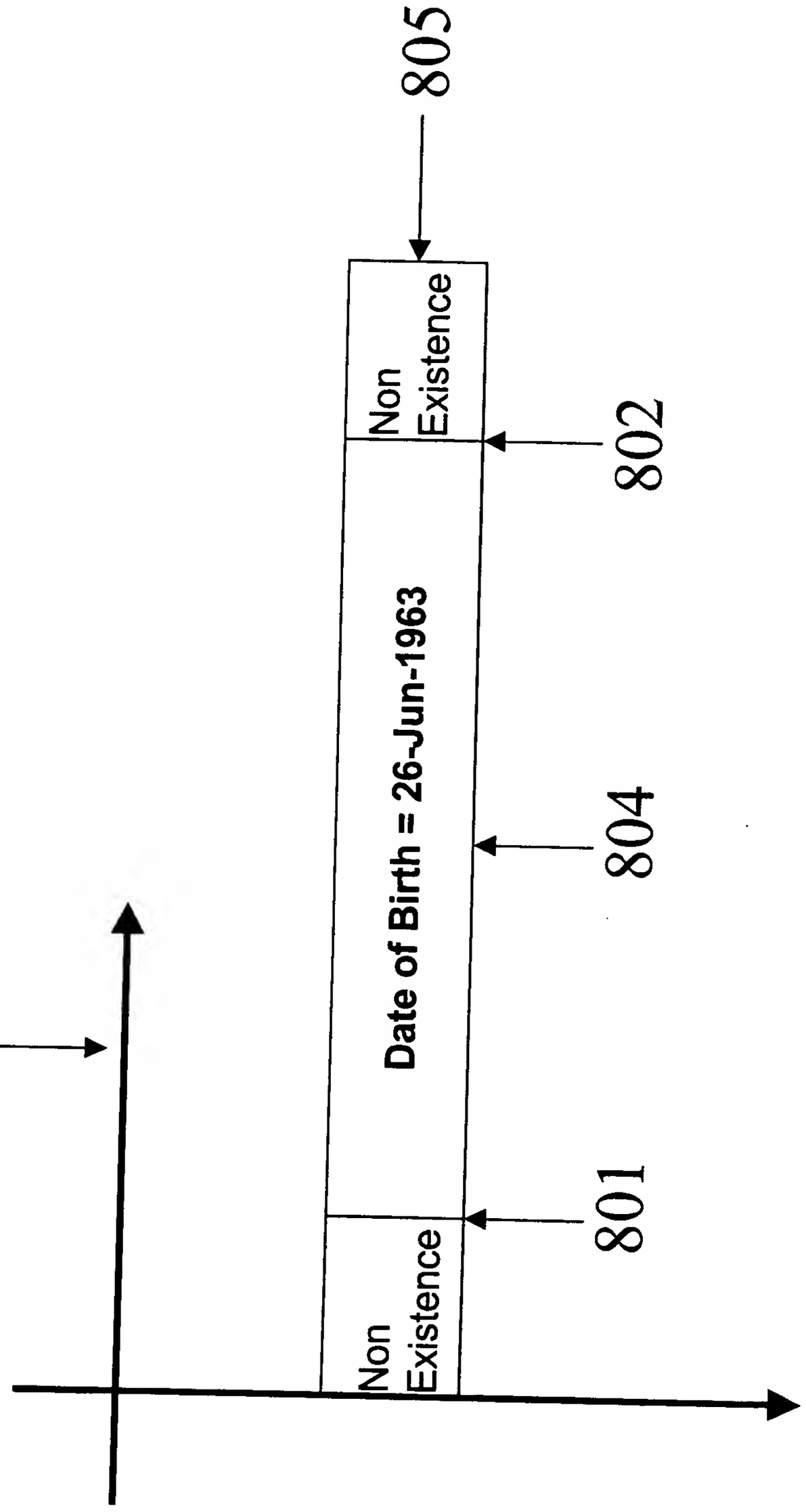

805
Non Existence
802
Date of Birth = 26-Jun-1963
804
803
801
Non Existence

FIG. 8

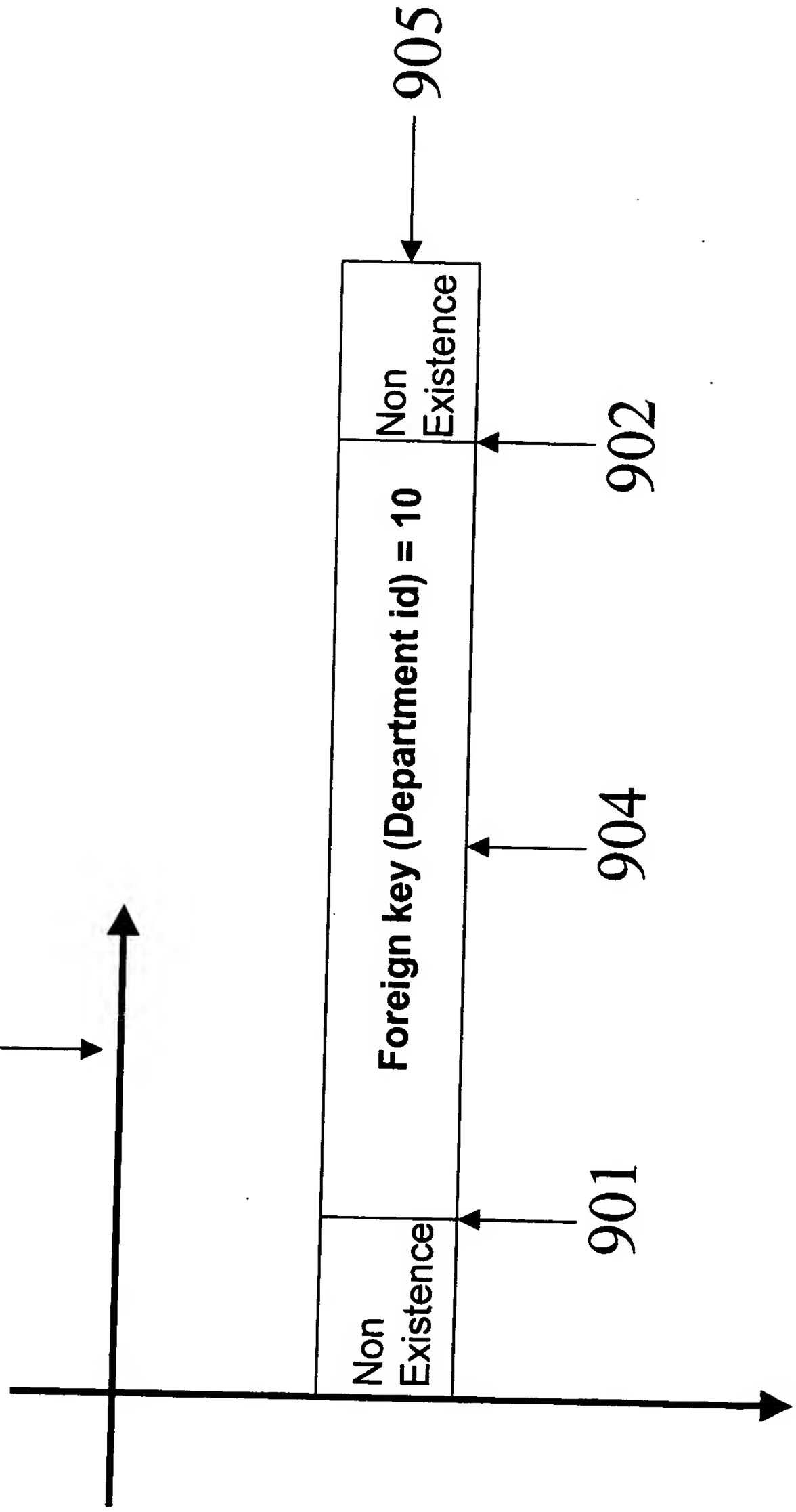

905
Non Existence
902
Foreign key (Department id) = 10
904
903
Non Existence
901

FIG. 9

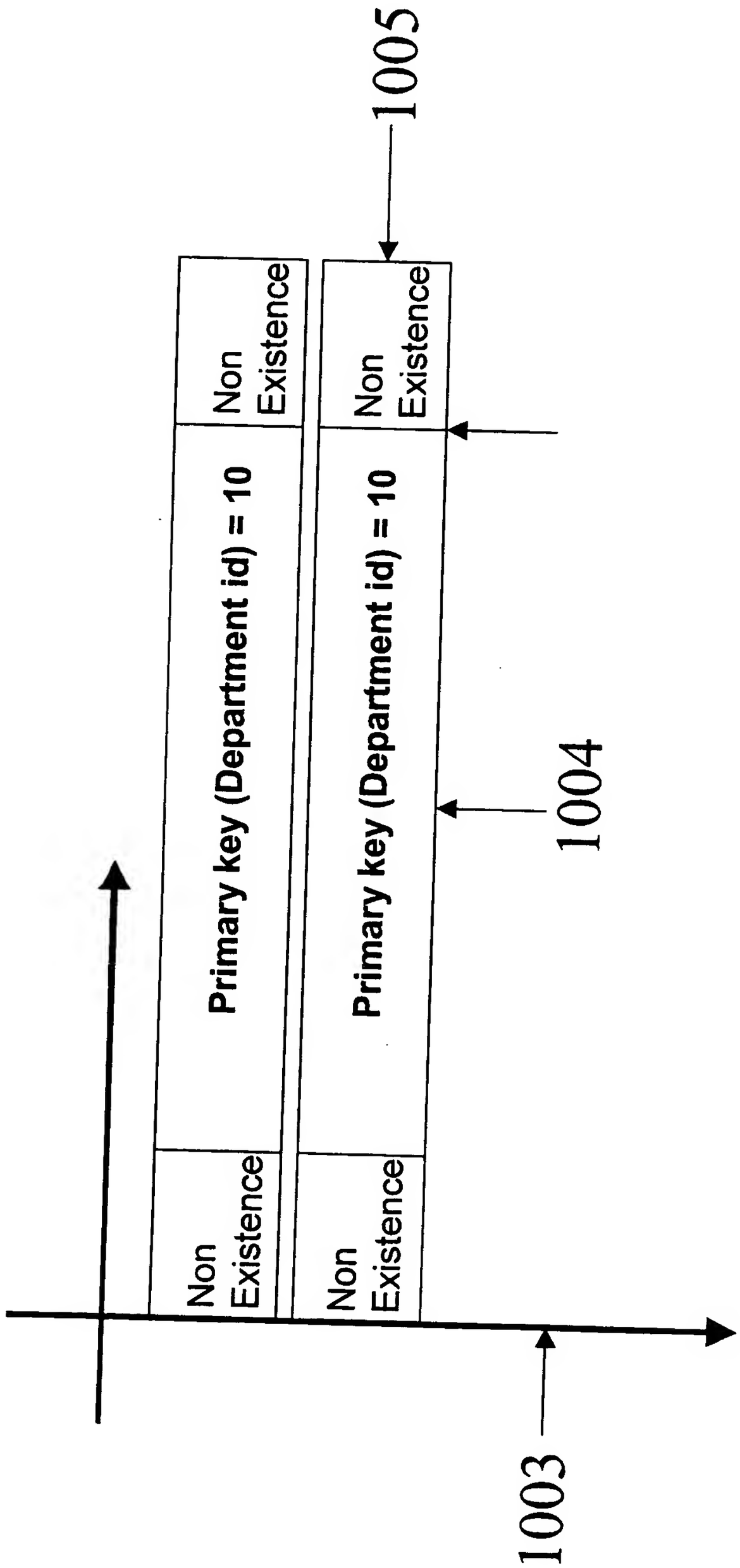

1005
Non Existence
Primary key (Department id) = 10
Non Existence
1004
Non Existence
Primary key (Department id) = 10
Non Existence
1003

FIG. 10

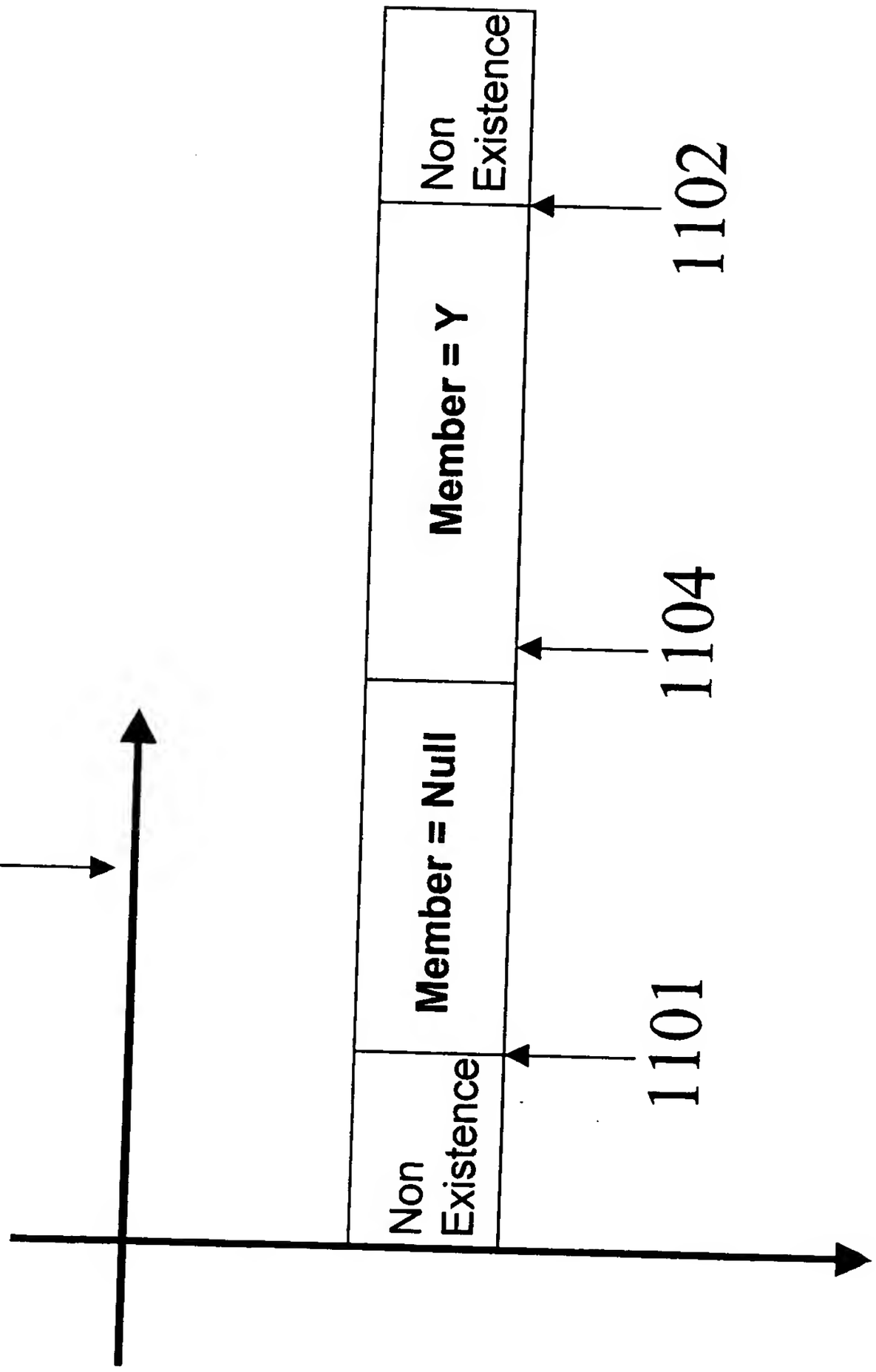

Non Existence
Member = Y
Member = Null
Non Existence
1102
1104
1101
1103

FIG. 11

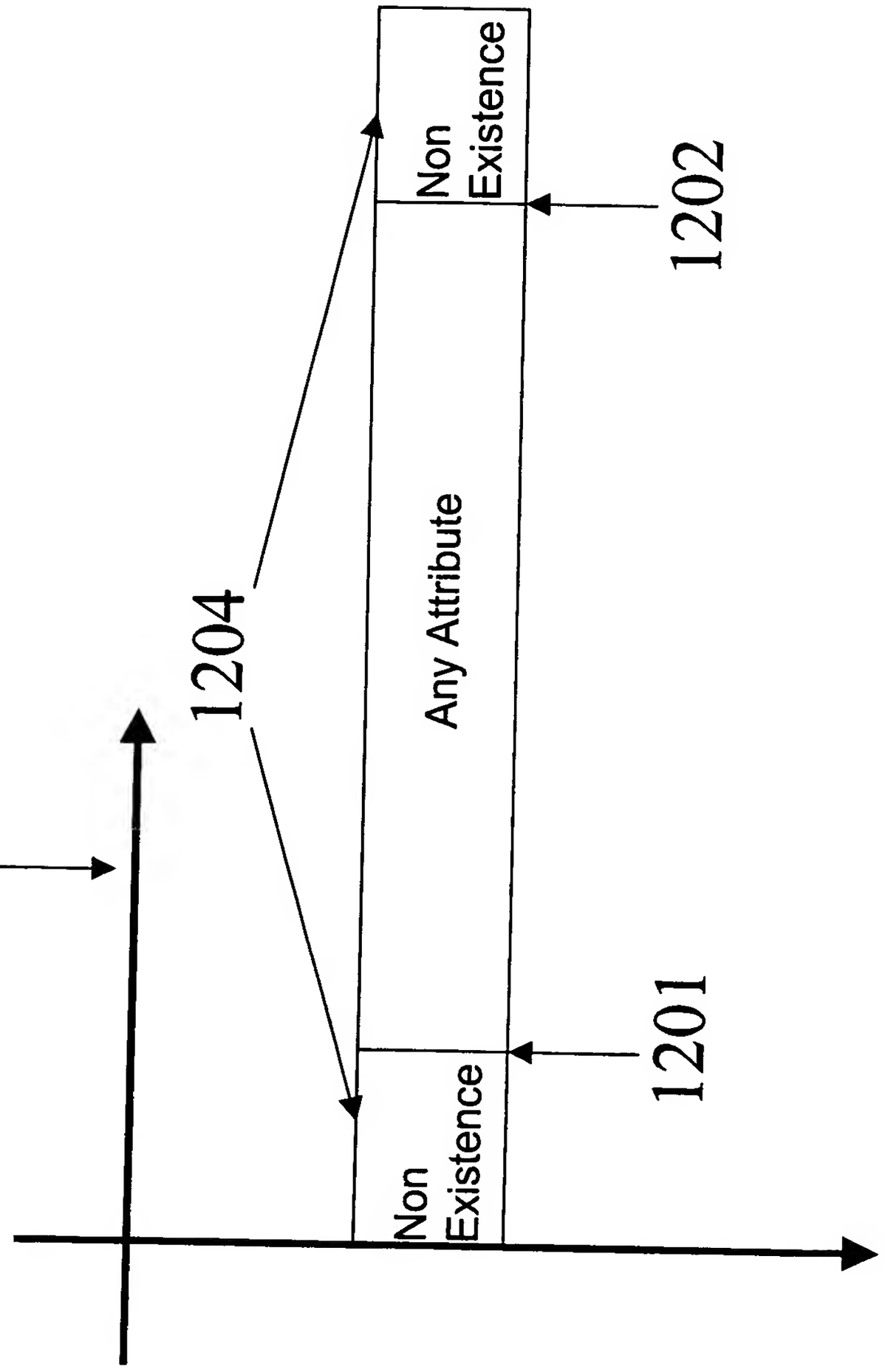

Non Existence
1202
Any Attribute
1204
1203
Non Existence
1201

FIG. 12

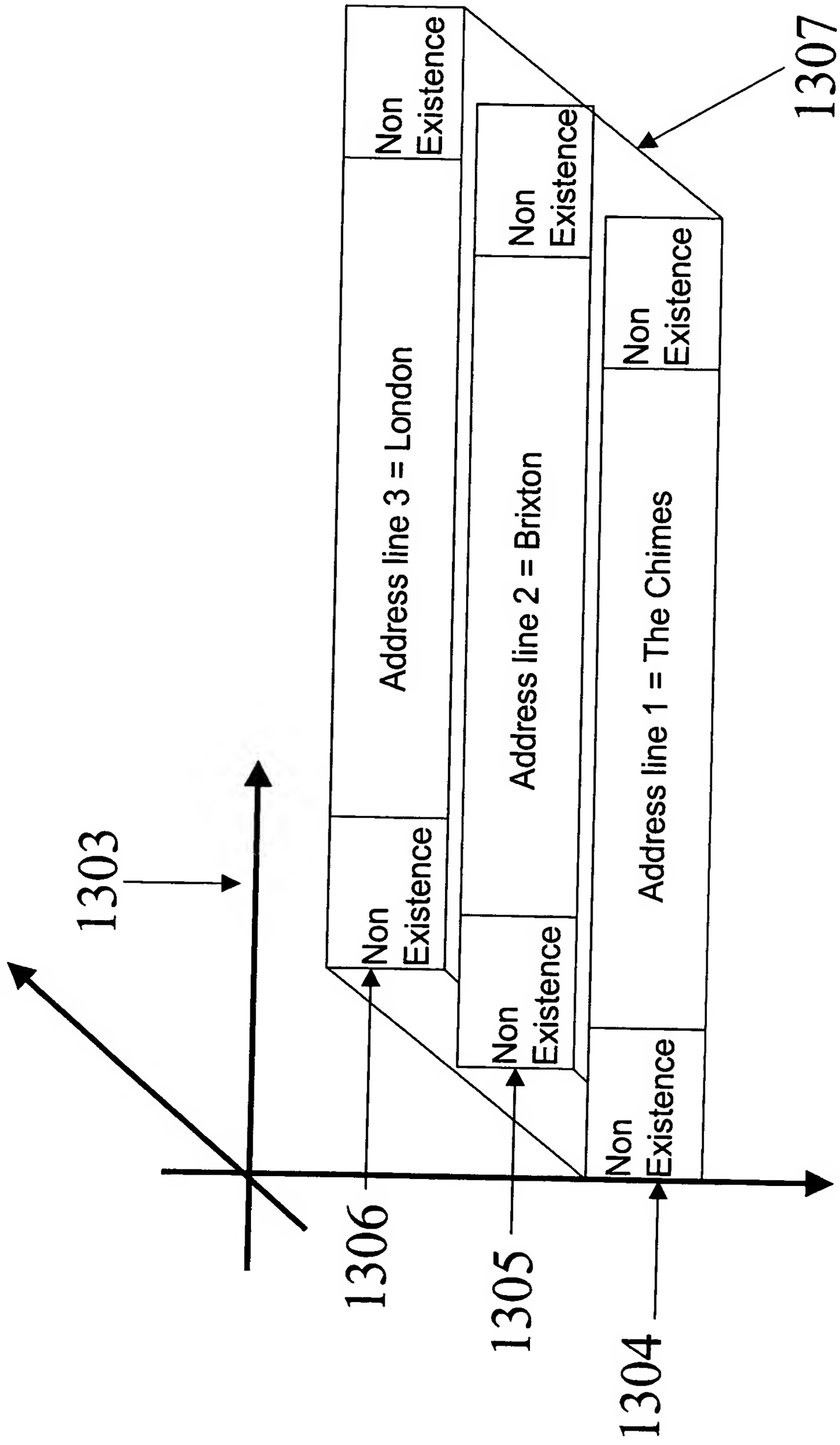

1307
1303
1306
1305
1304
Non Existence
Non Existence
Non Existence
Non Existence
Non Existence
Non Existence
Address line 3 = London
Address line 2 = Brixton
Address line 1 = The Chimes

FIG. 13

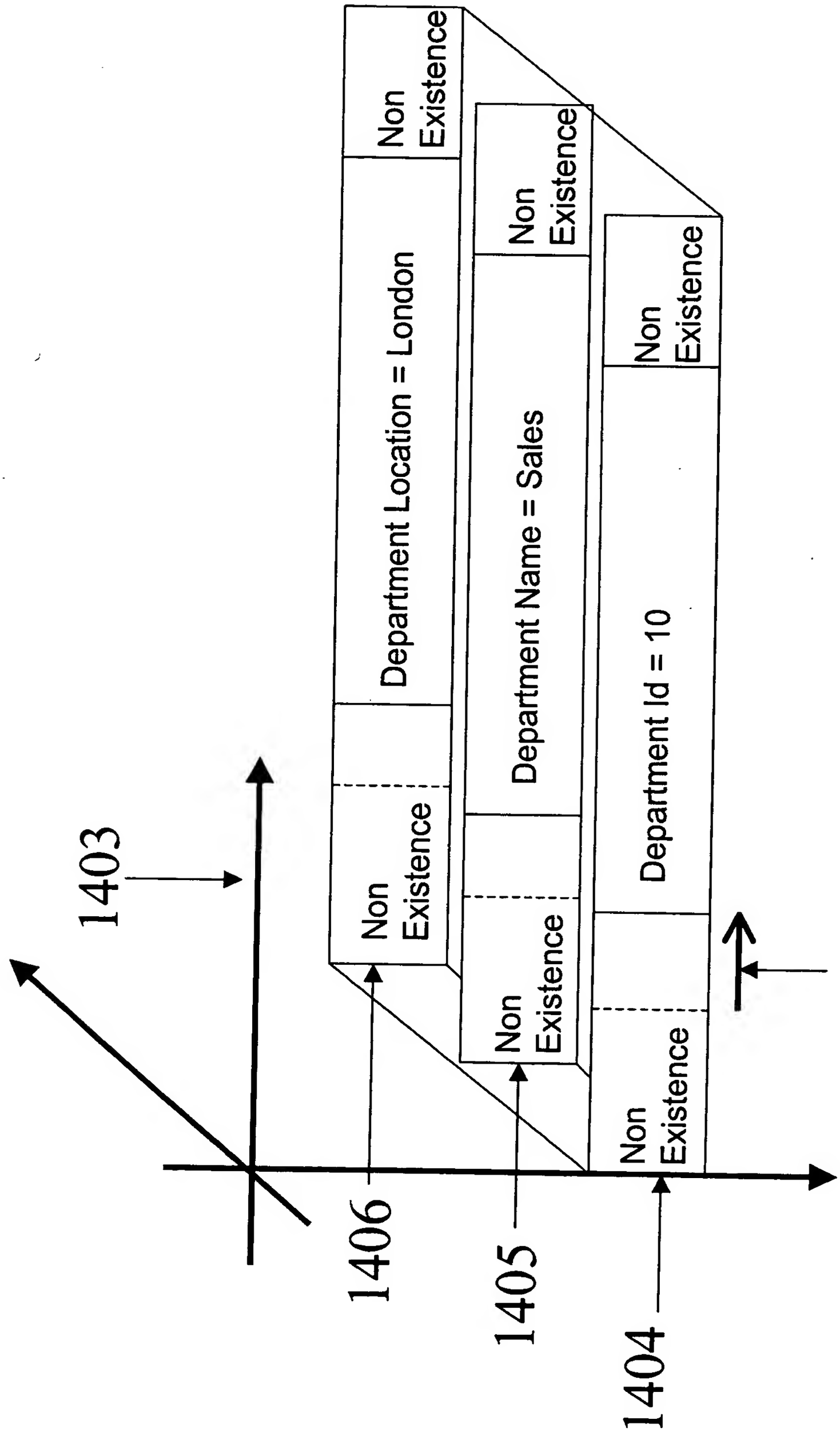

Non Existence
Department Location = London
Non Existence
Department Name = Sales
Non Existence
Department Id = 10
Non Existence
Non Existence
1403
1407
1406
1405
1404

FIG. 14

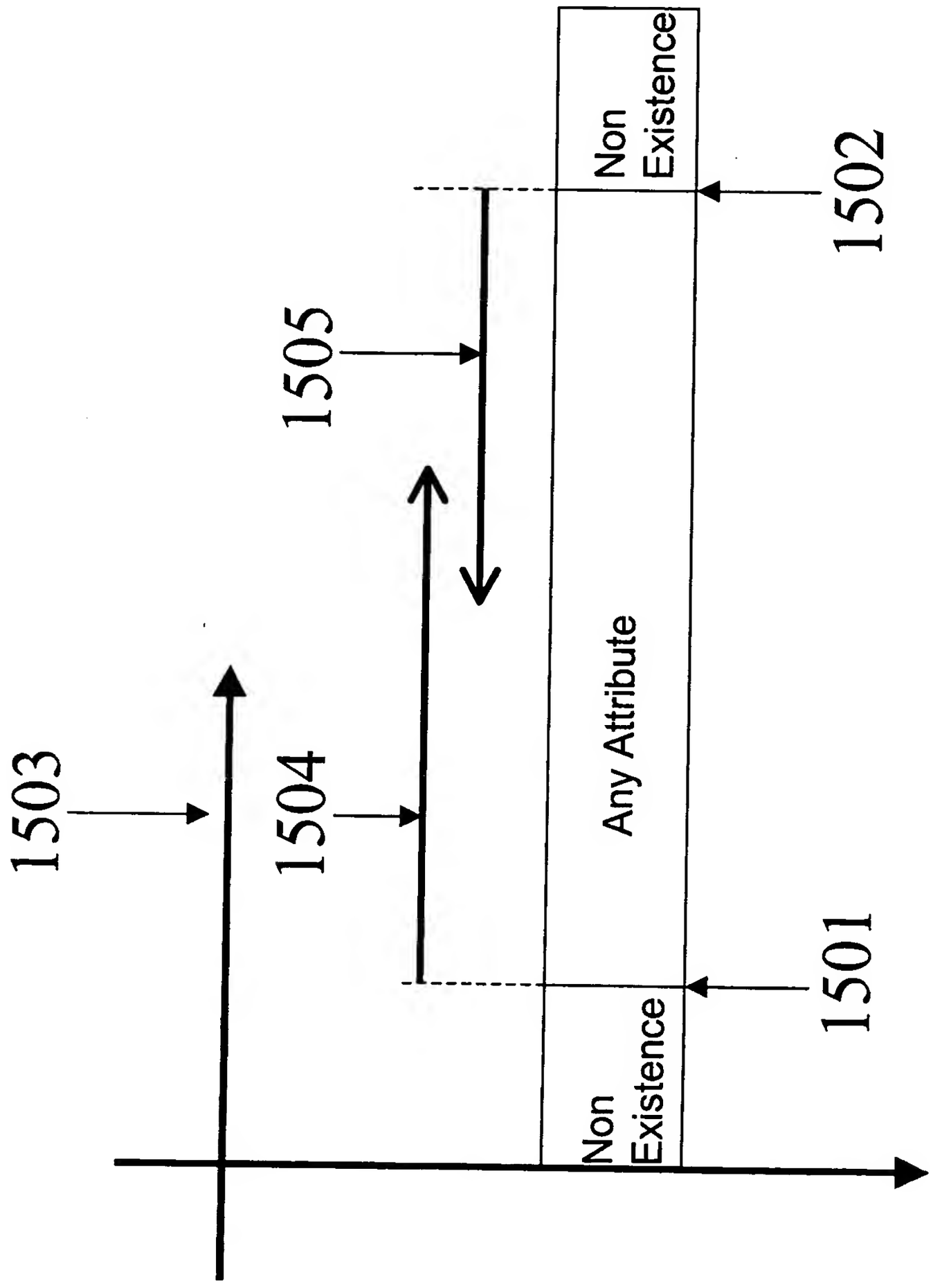


FIG. 15

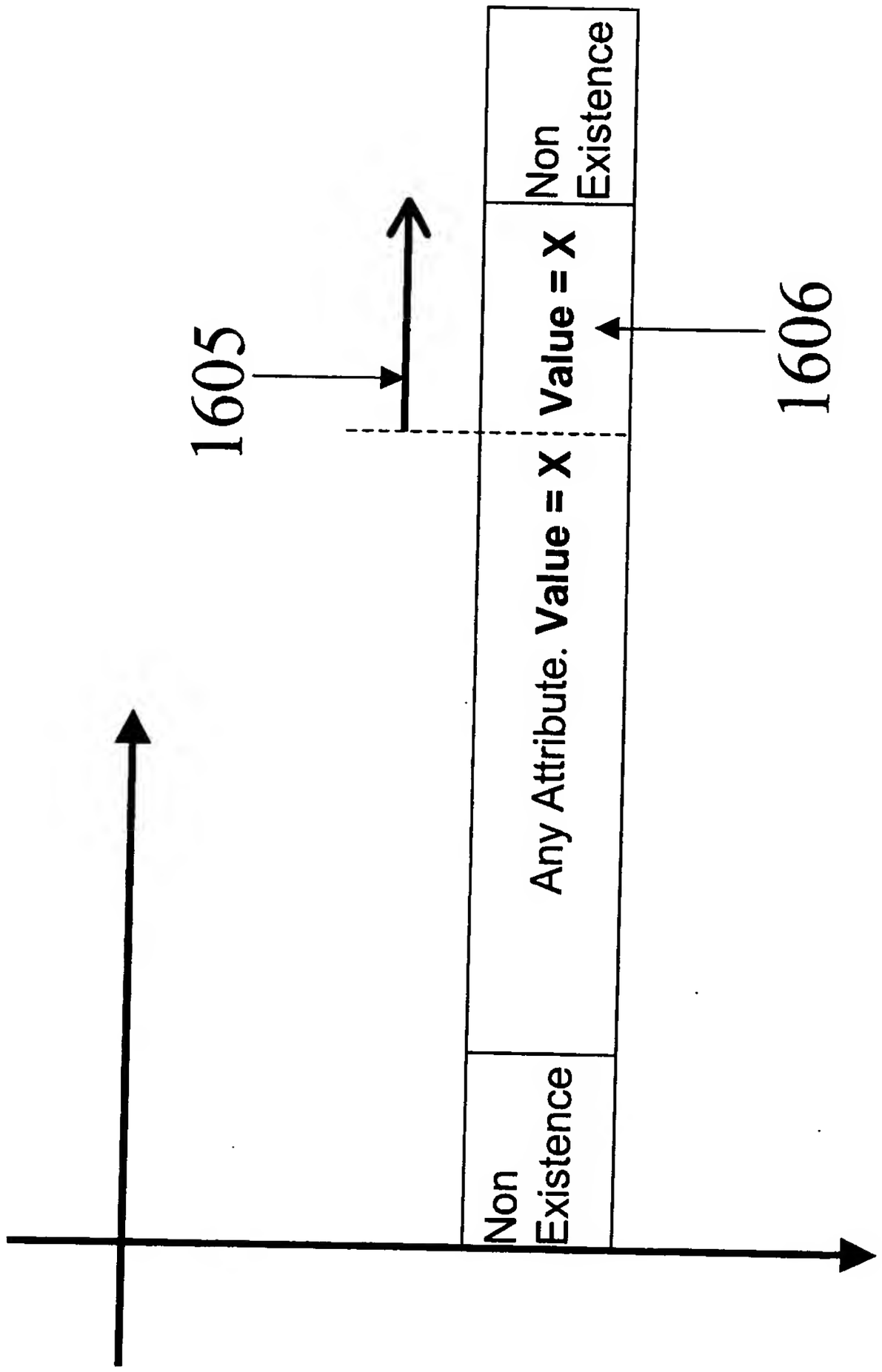

Non Existence
Value = X
Any Attribute. Value = X
1605
1606
Non Existence

FIG. 16a

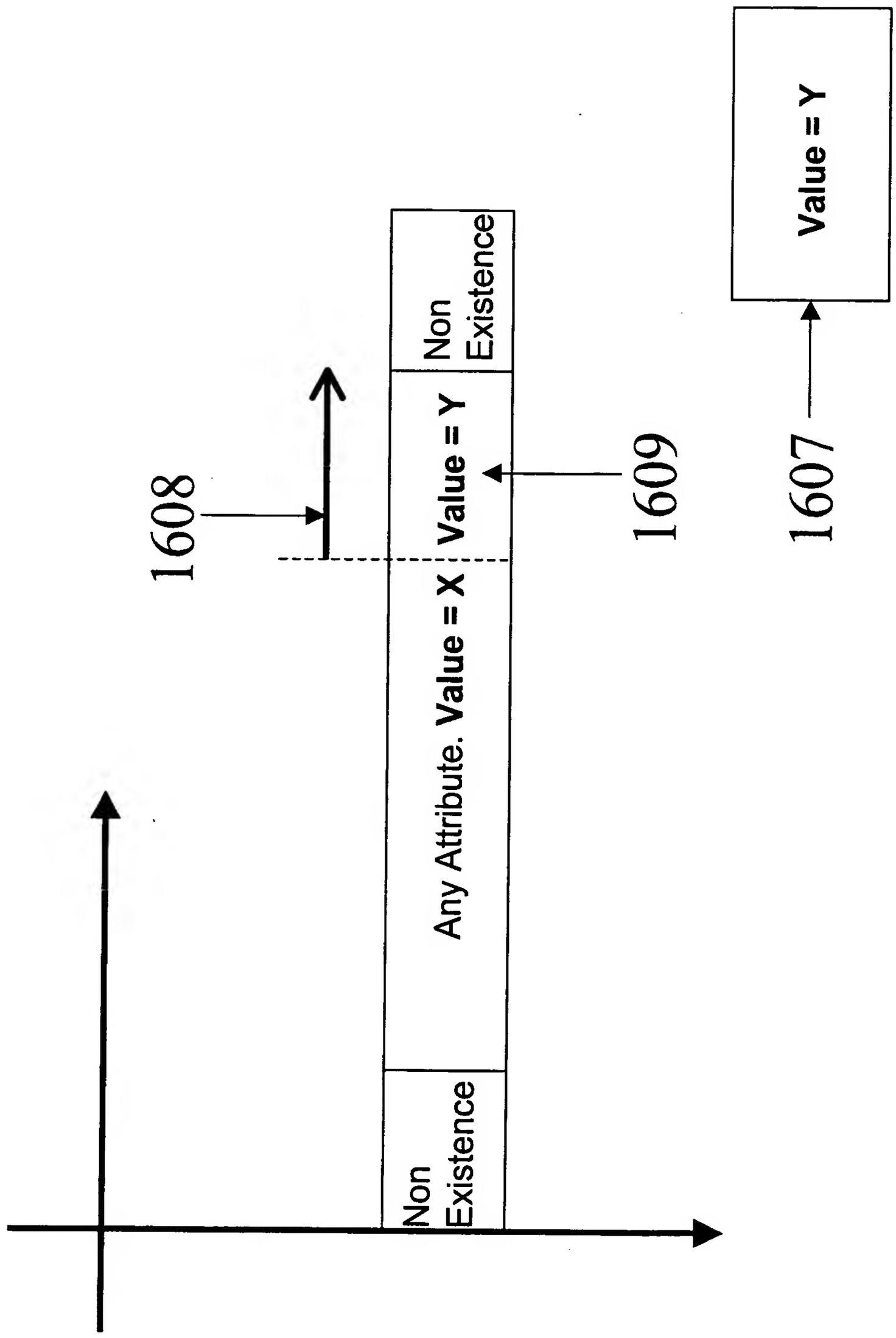

Value = Y
Non Existence
Value = Y
Any Attribute. Value = X
Non Existence
1608
1609
1607

FIG. 16b

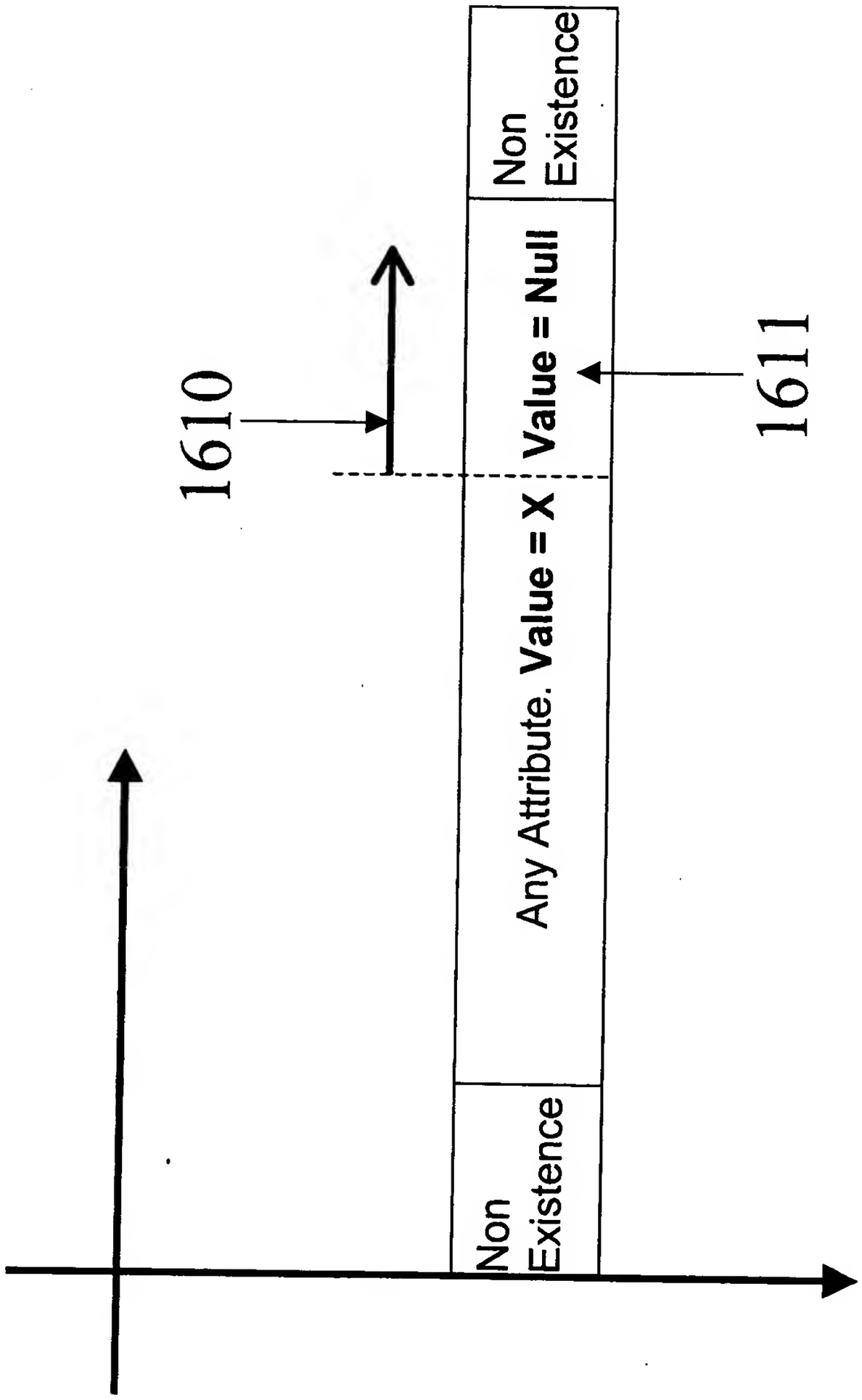

Non Existence
Any Attribute. Value = Null
Any Attribute. Value = X
Non Existence
1610
1611

FIG. 16c

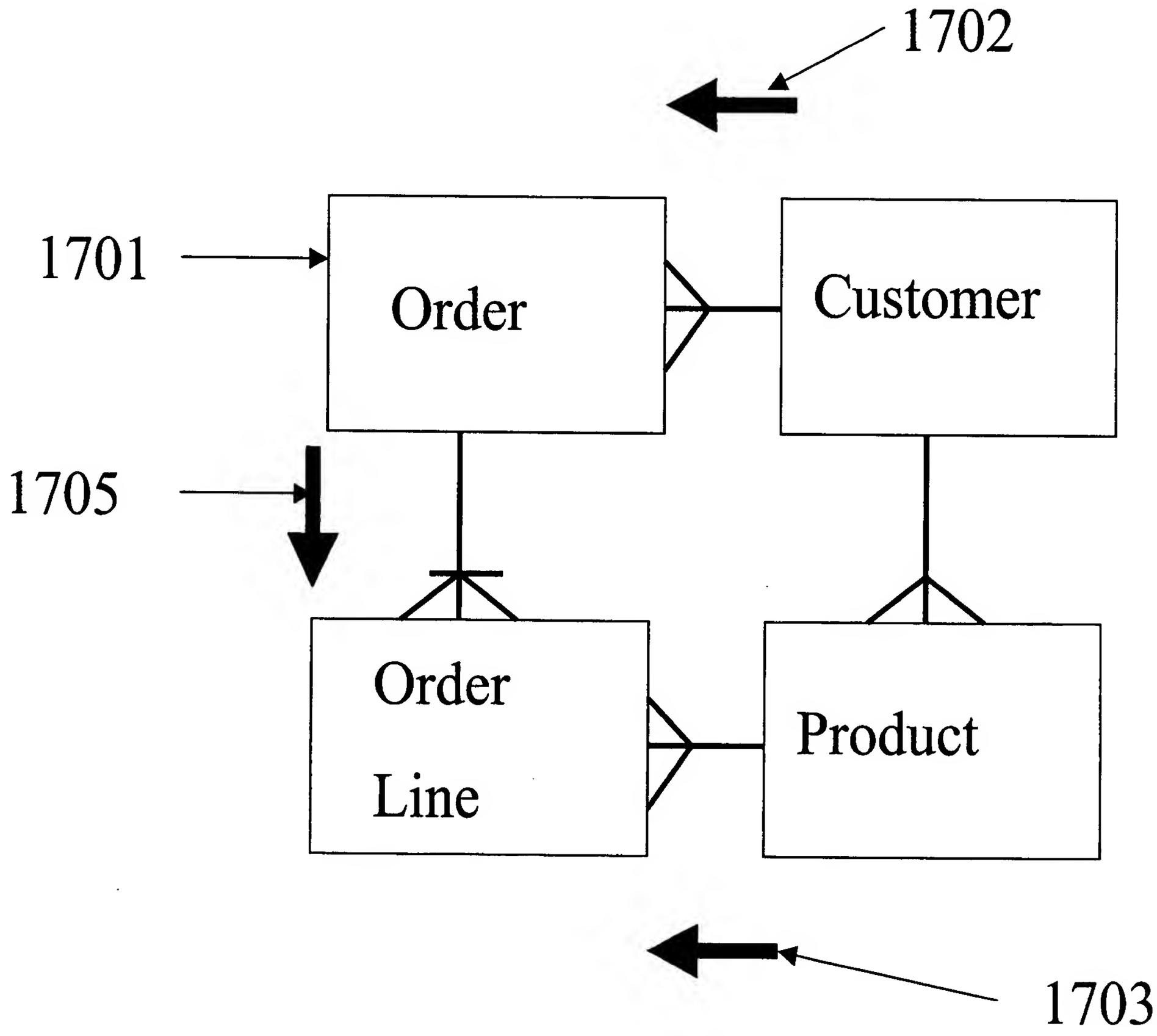


FIG. 17

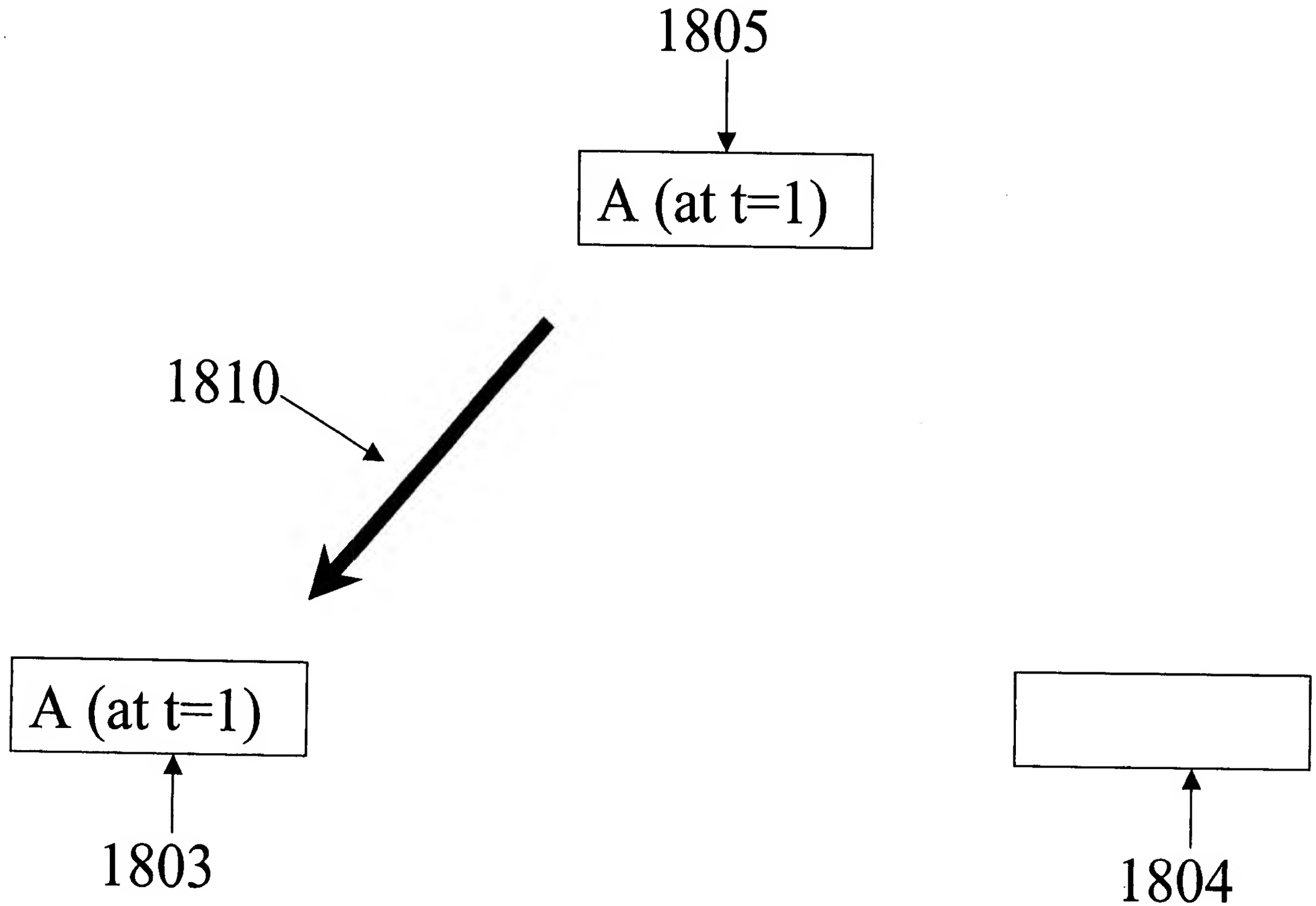


FIG. 18a

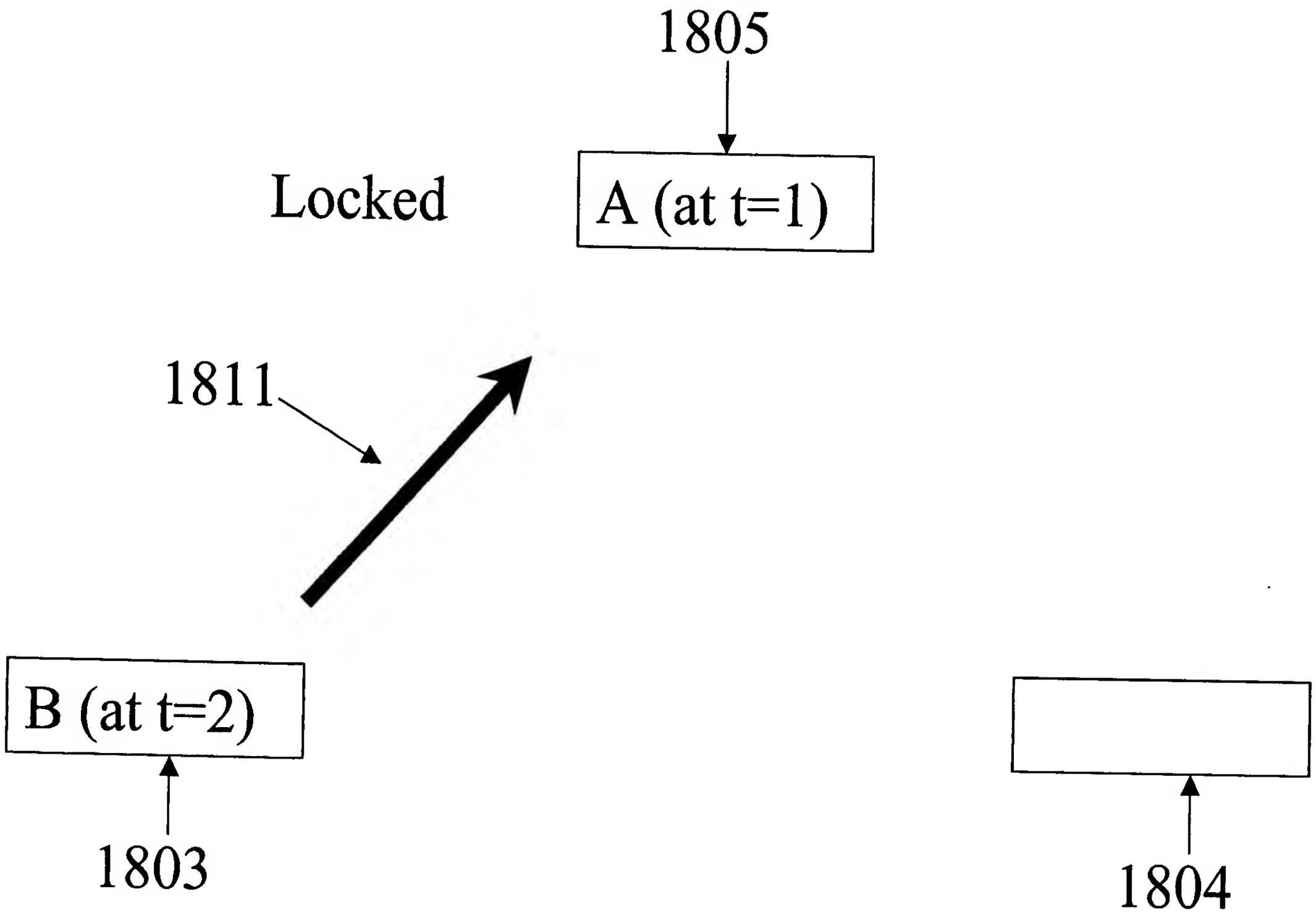


FIG. 18b

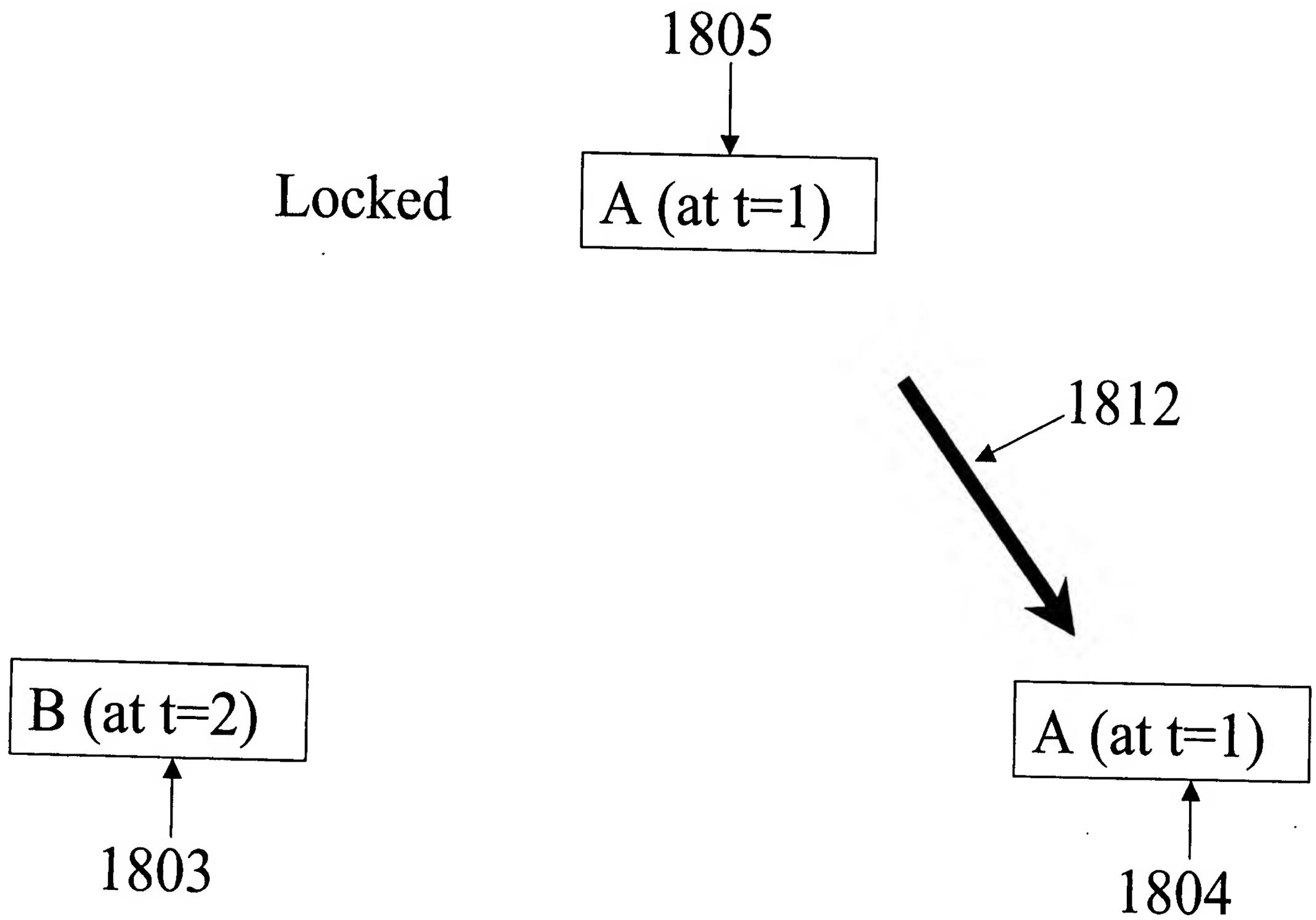


FIG. 18c

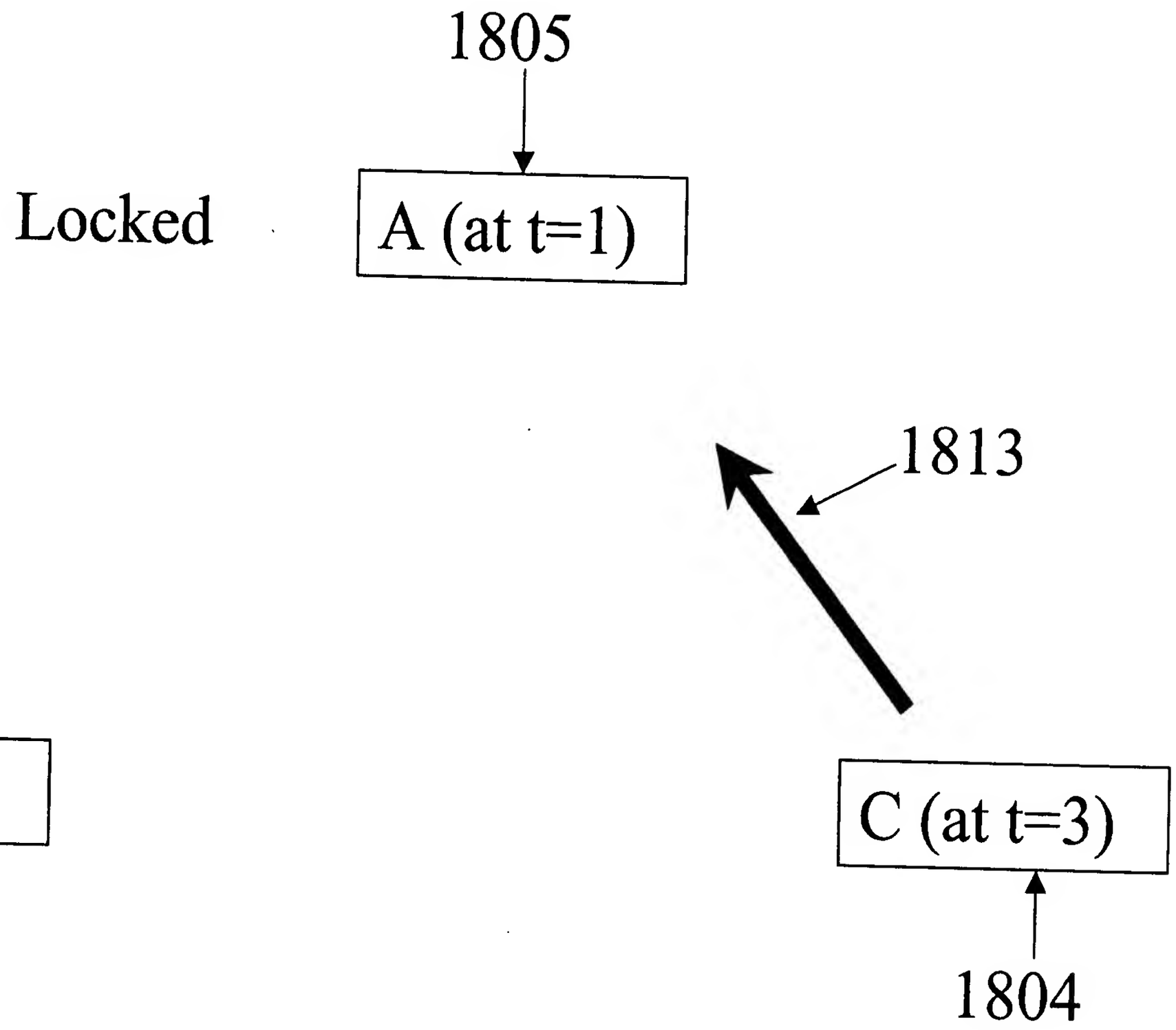


FIG. 18d

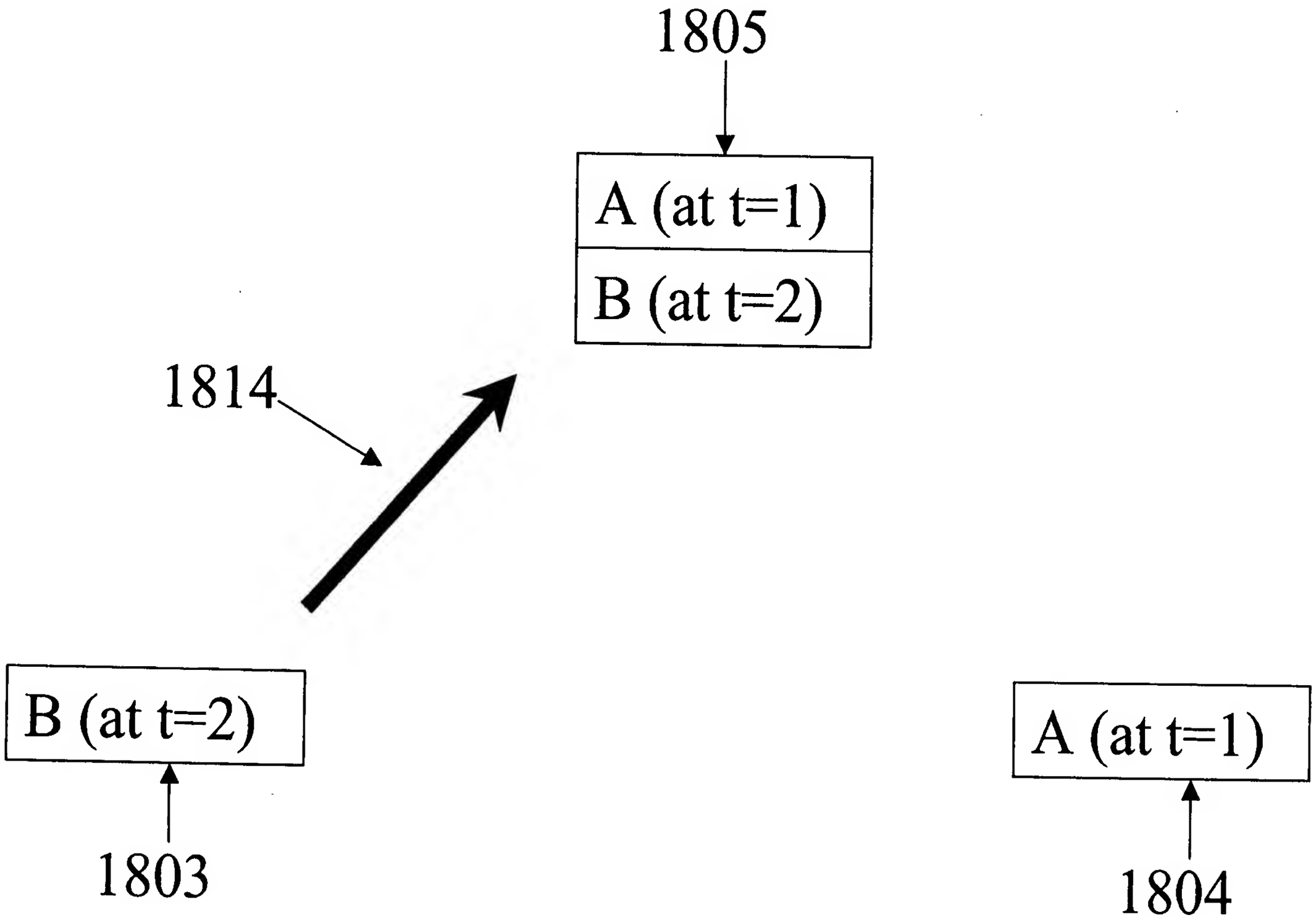


FIG. 18e

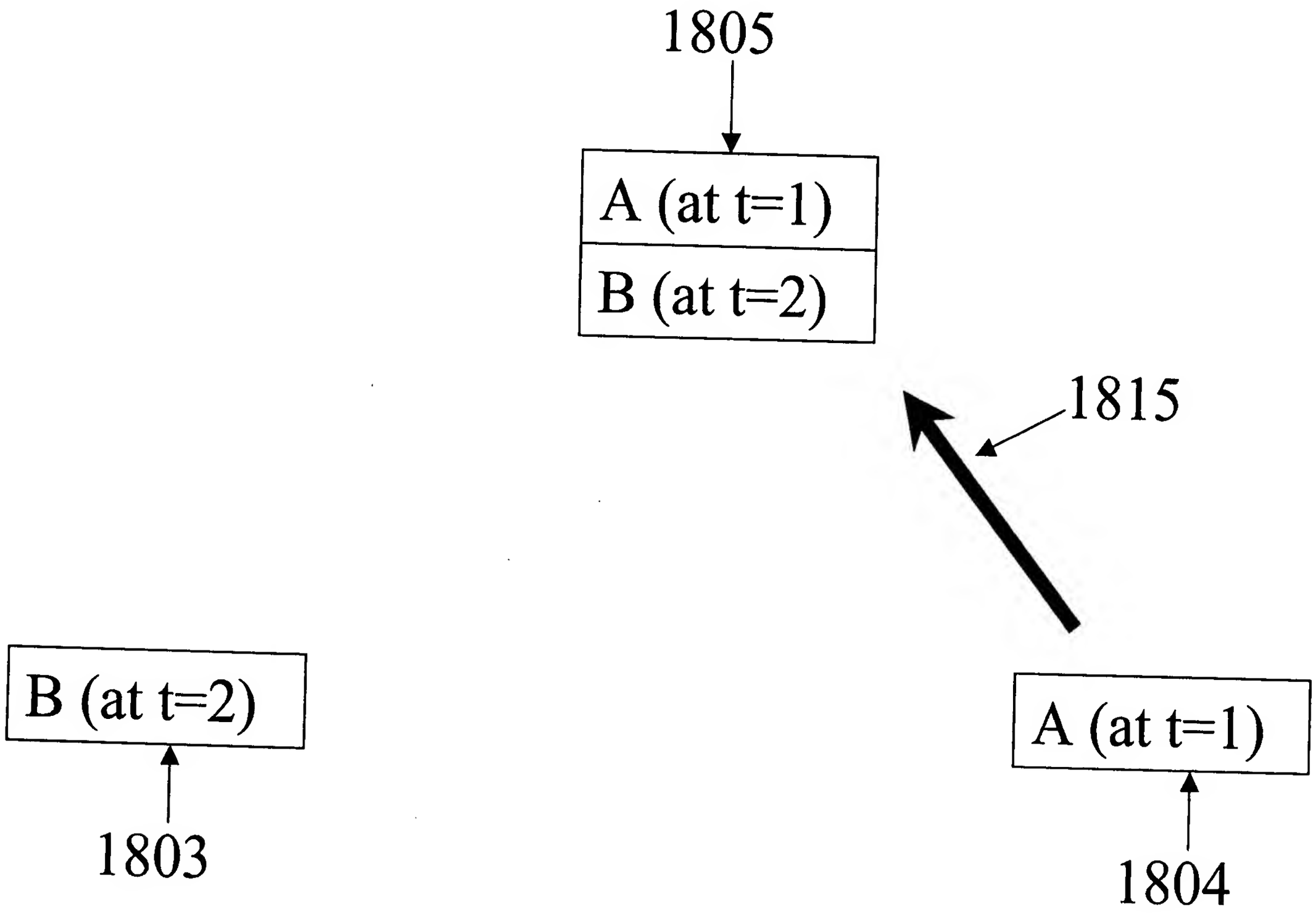


FIG. 18f

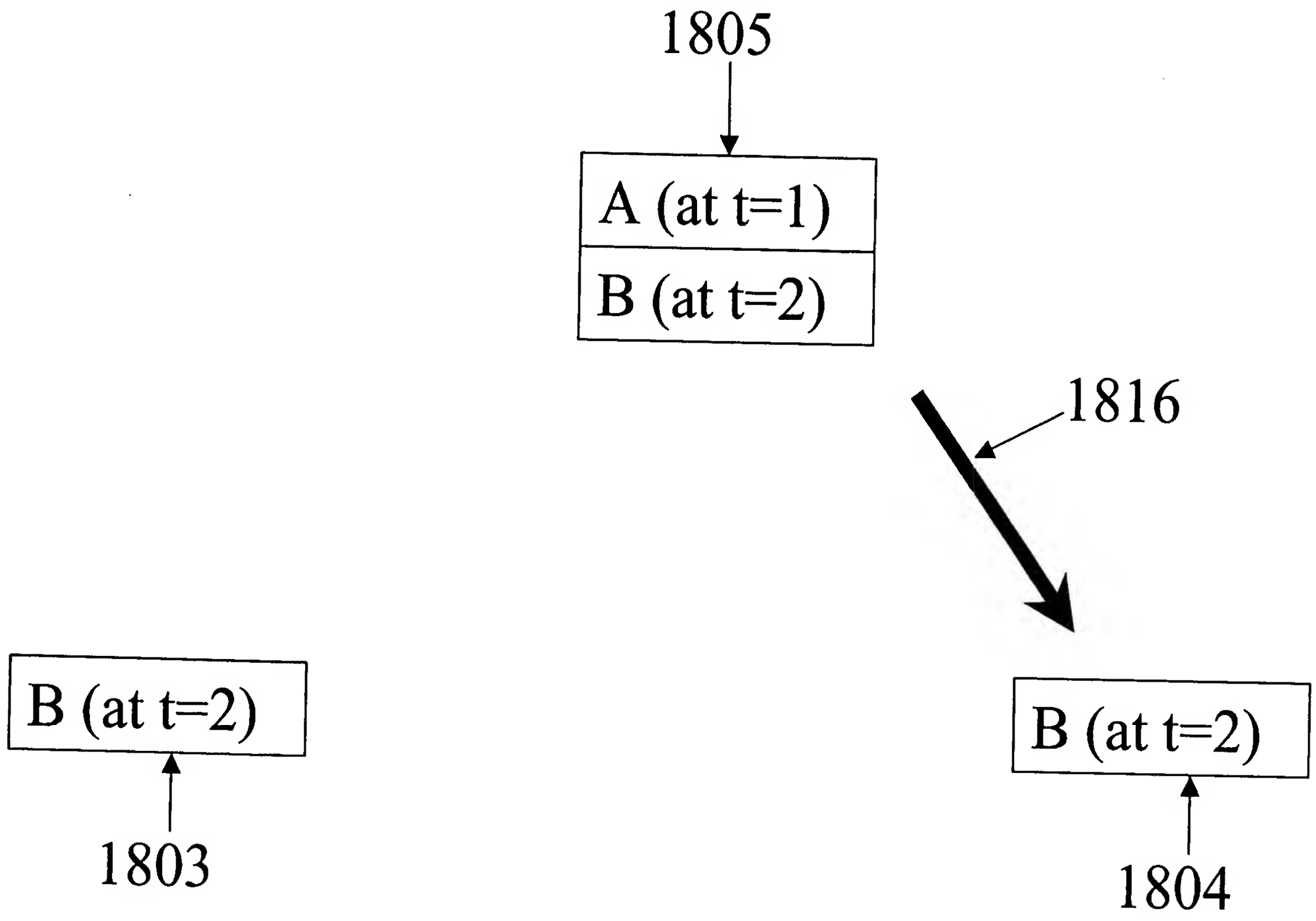


FIG. 18g

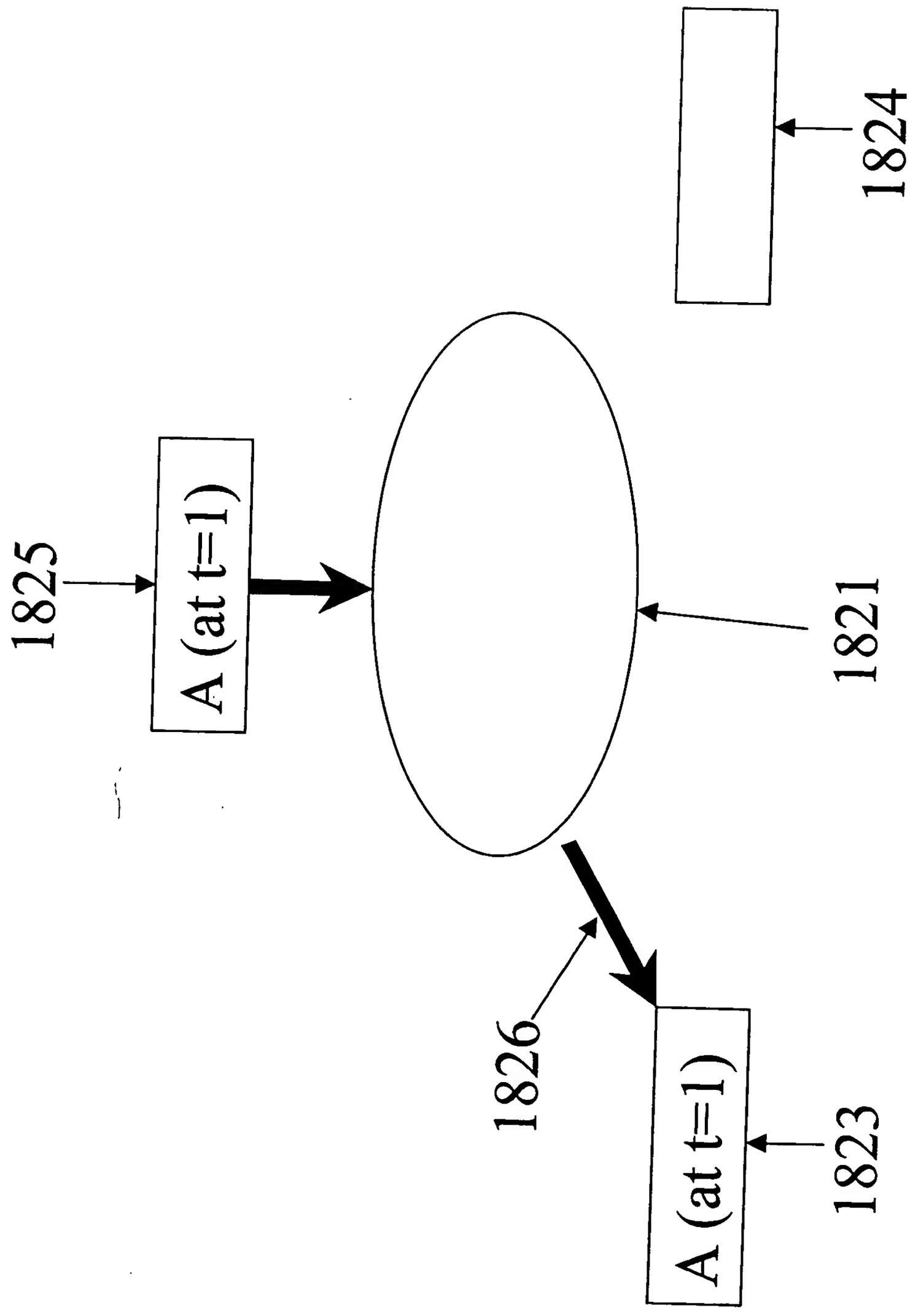


FIG. 18h

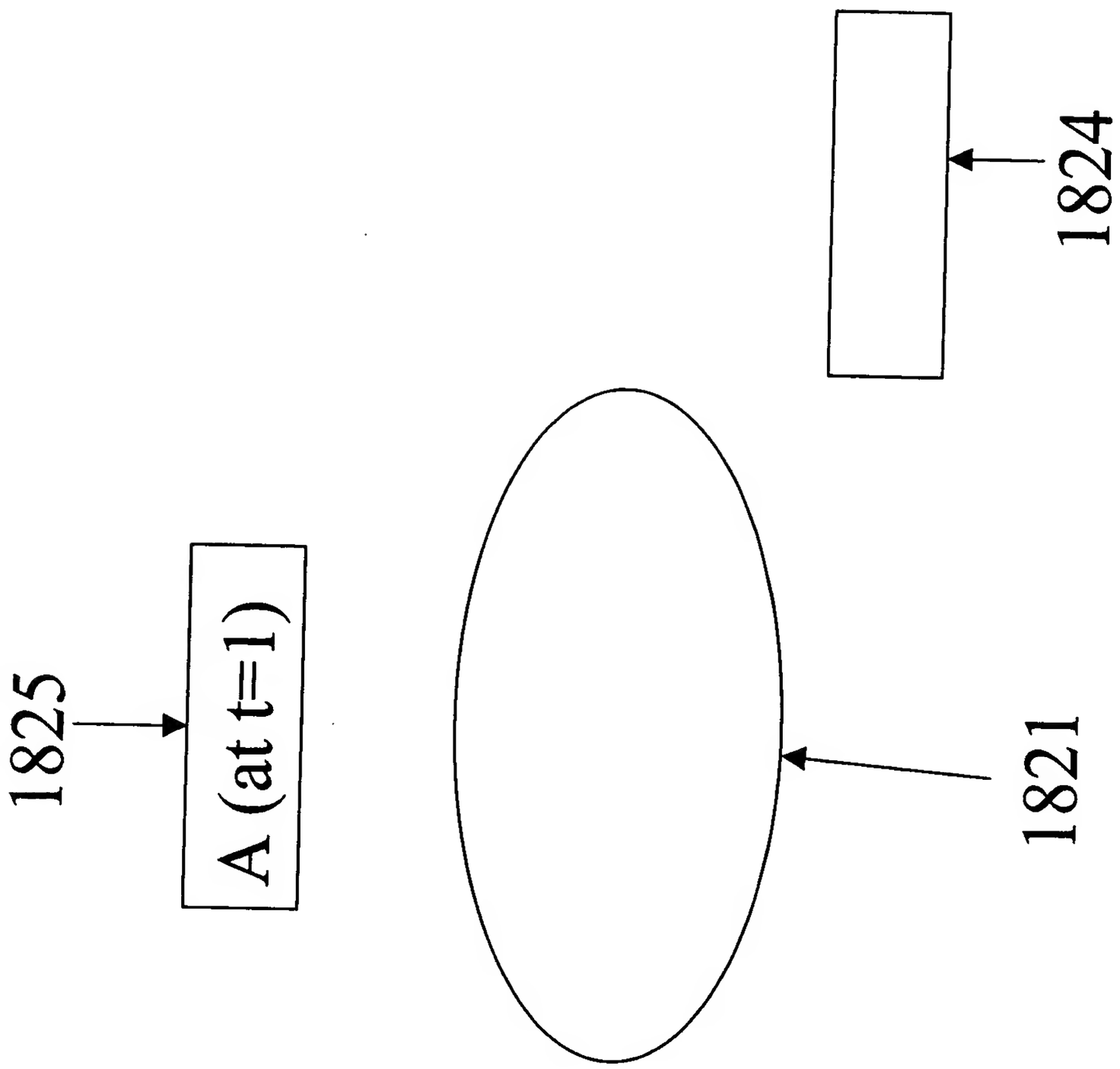


FIG. 18i

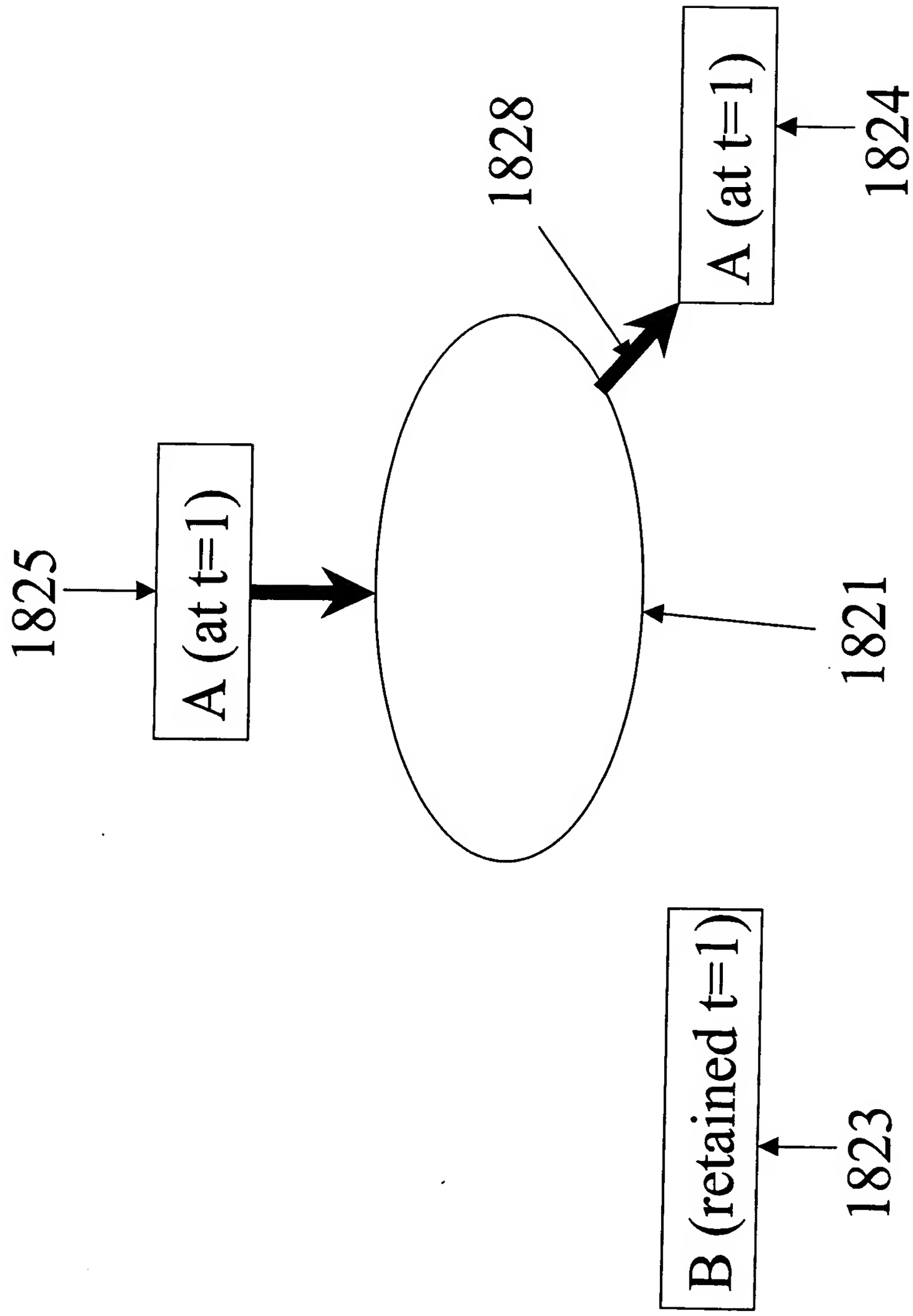


FIG. 18j

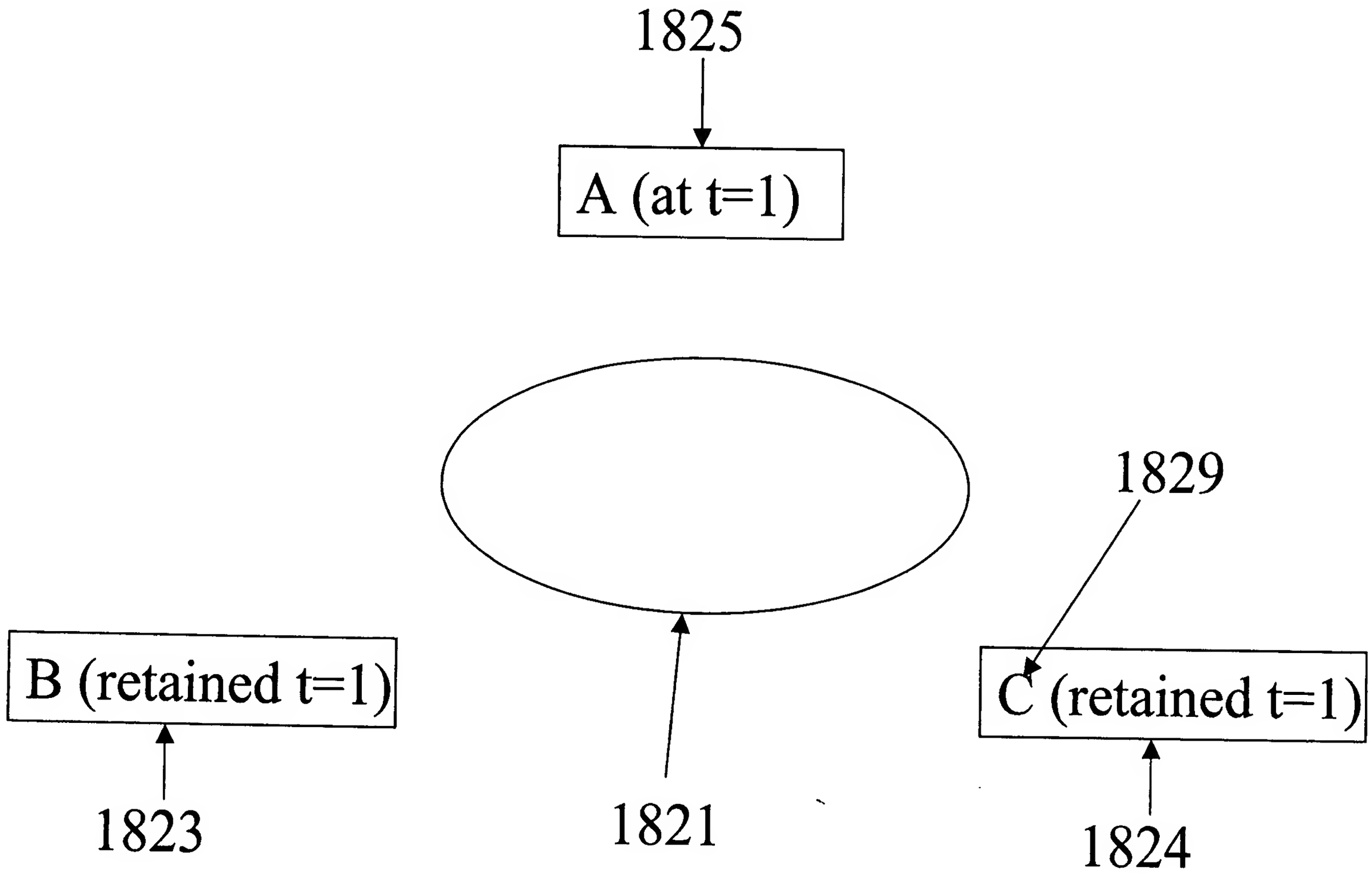


FIG. 18k

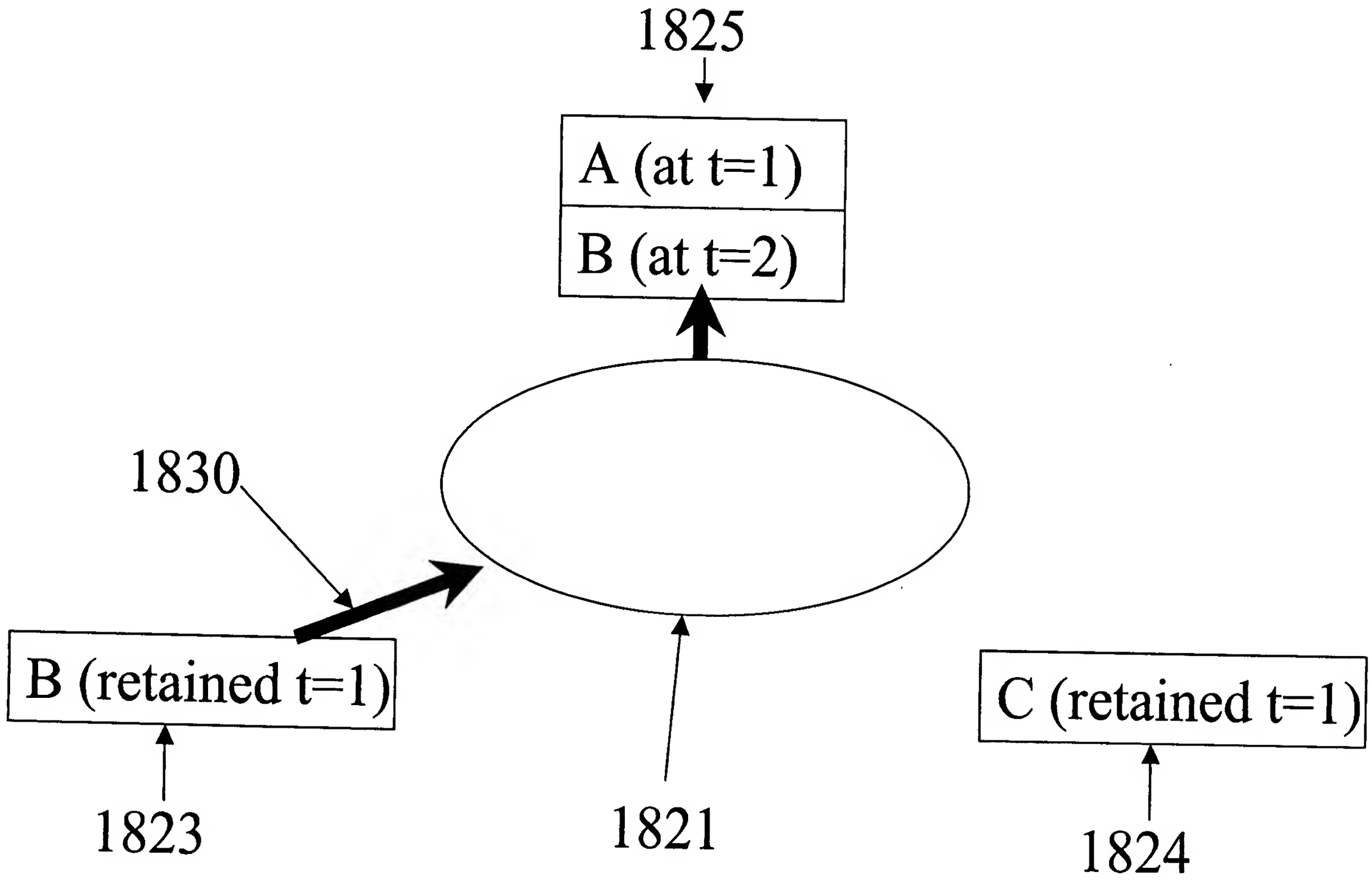

1825
A (at t=1)
B (at t=2)
1830
B (retained t=1)
C (retained t=1)
1823
1821
1824

FIG. 181

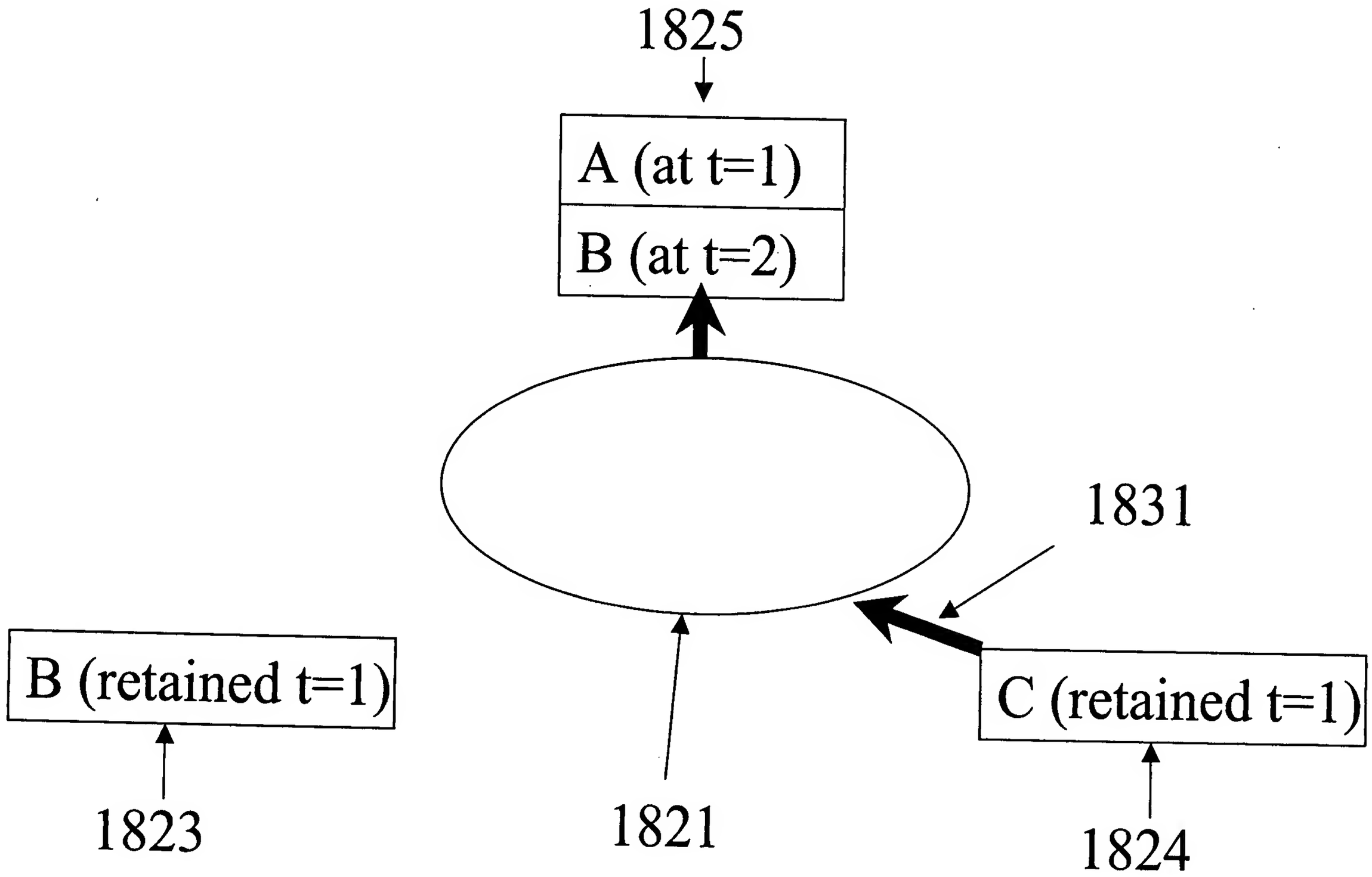

1825
A (at t=1)
B (at t=2)
1831
B (retained t=1)
C (retained t=1)
1823
1821
1824

FIG. 18m

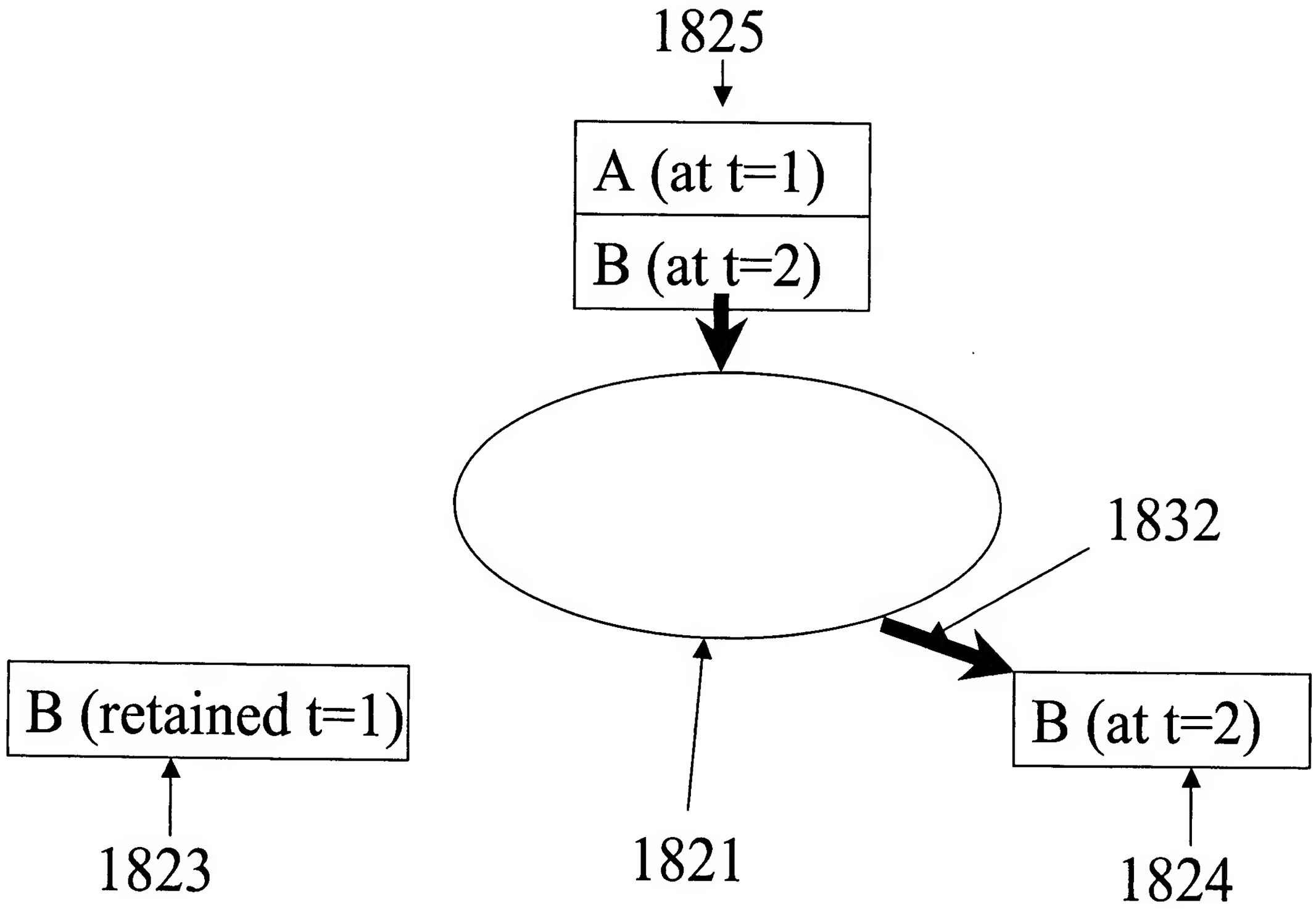


FIG. 18n

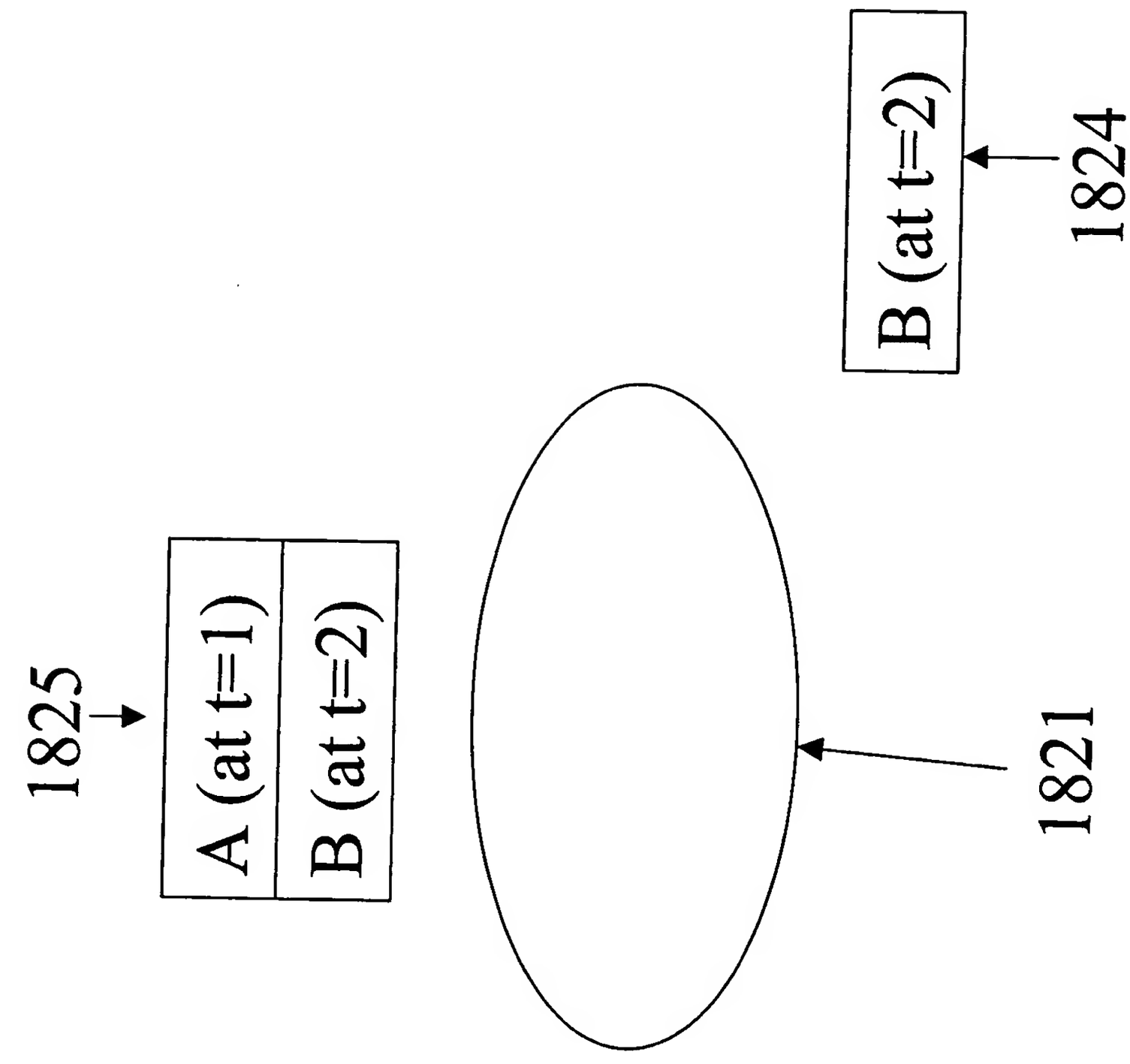


FIG. 18o

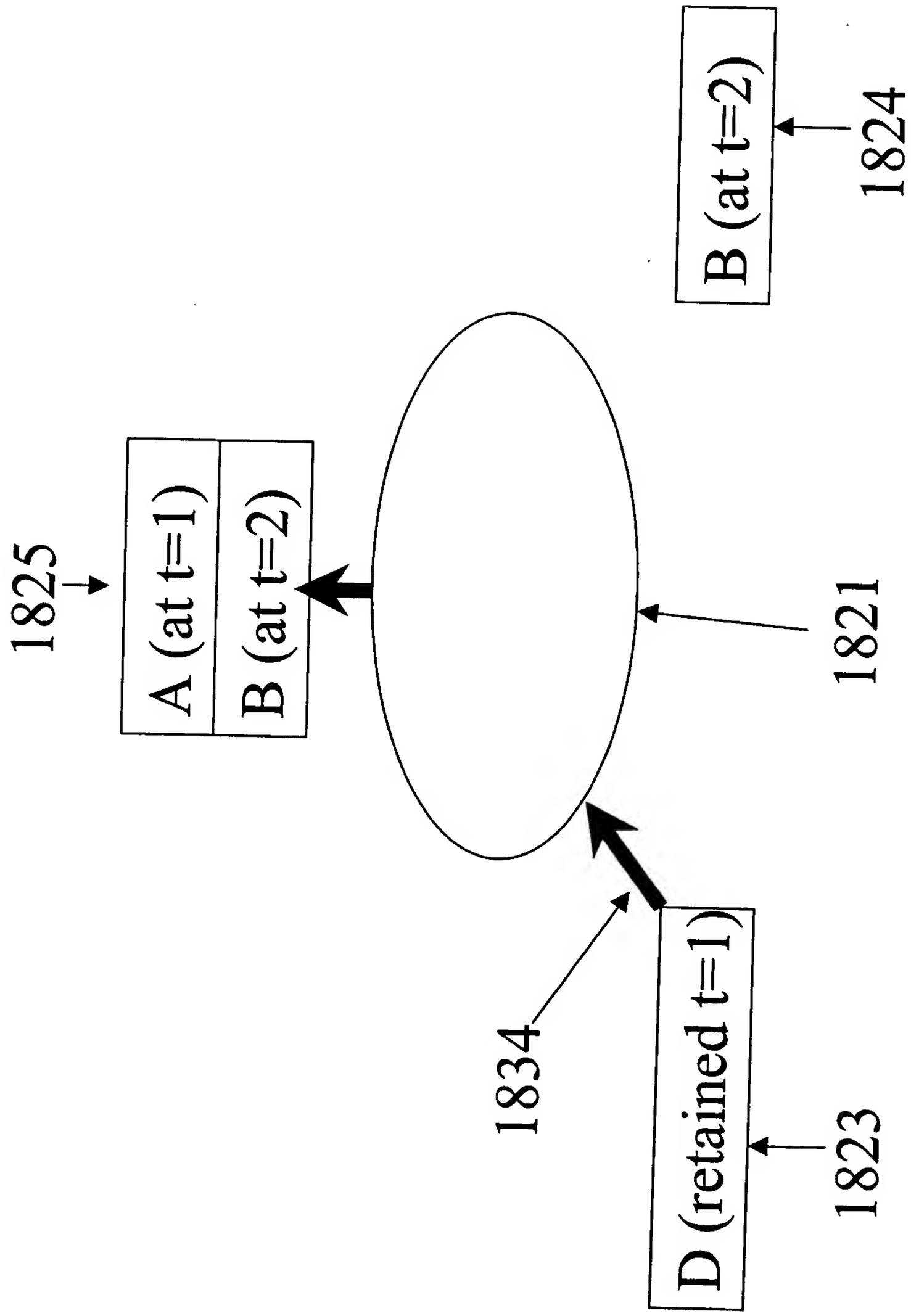


FIG. 18p

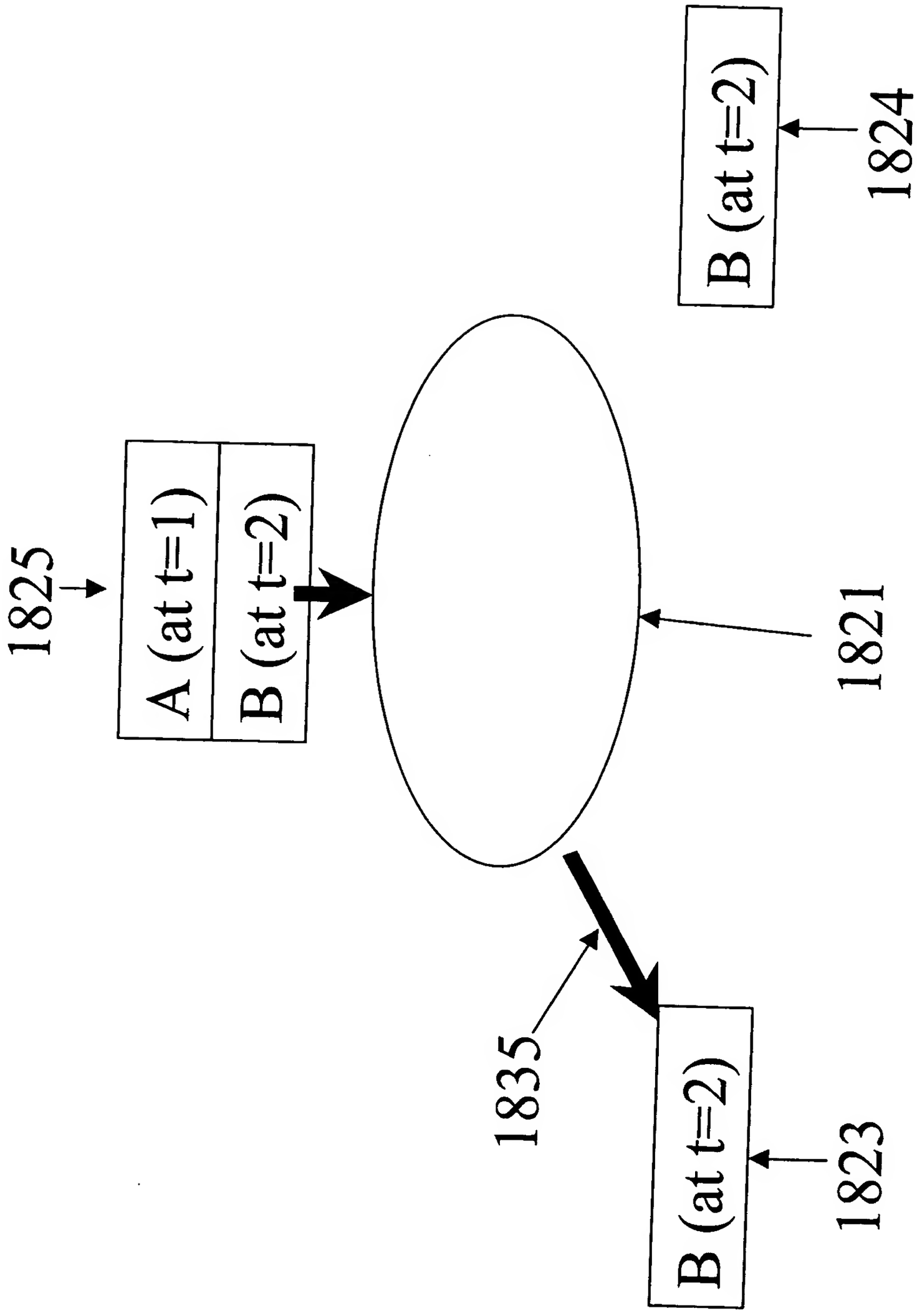


FIG. 18q

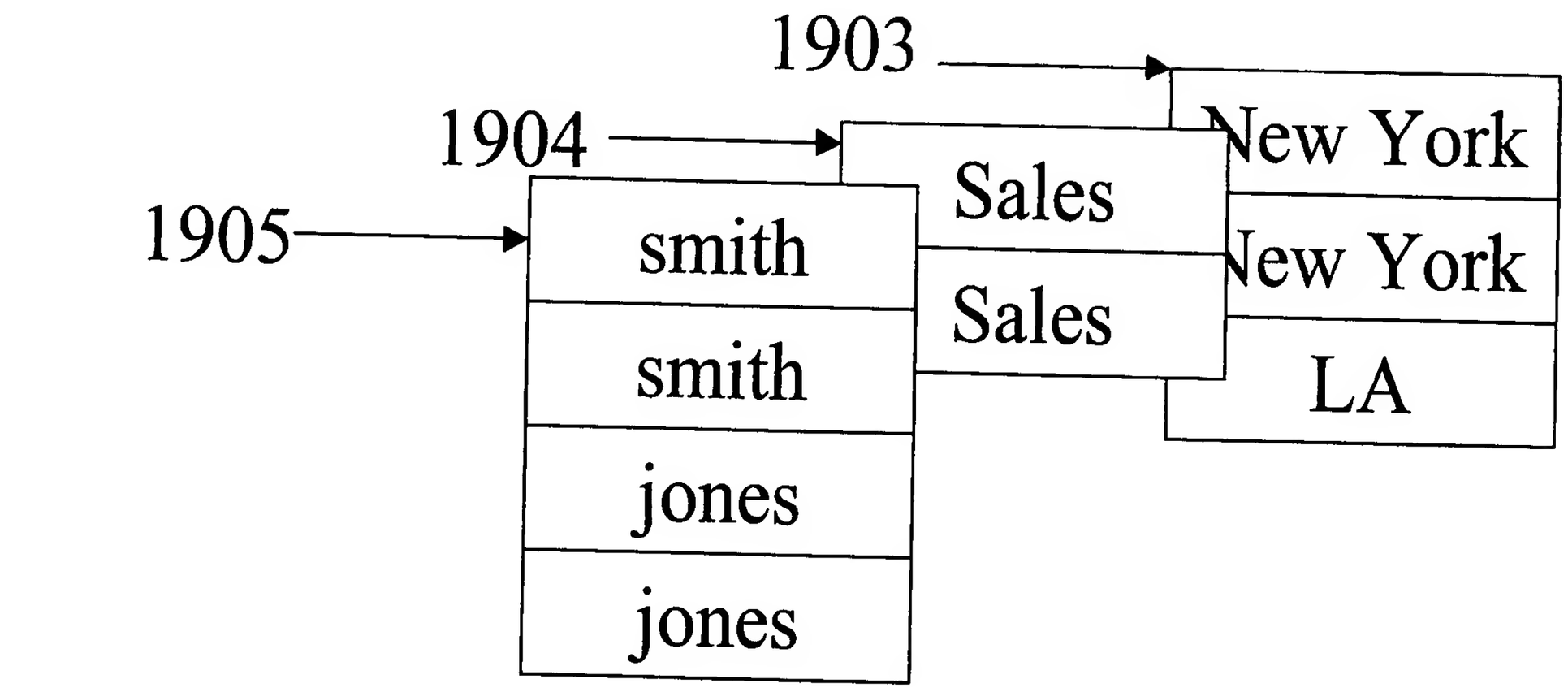

1903
1904
1905
smith
smith
jones
jones
Sales
Sales
New York
New York
LA
jones
1901
LA
1902

FIG. 19

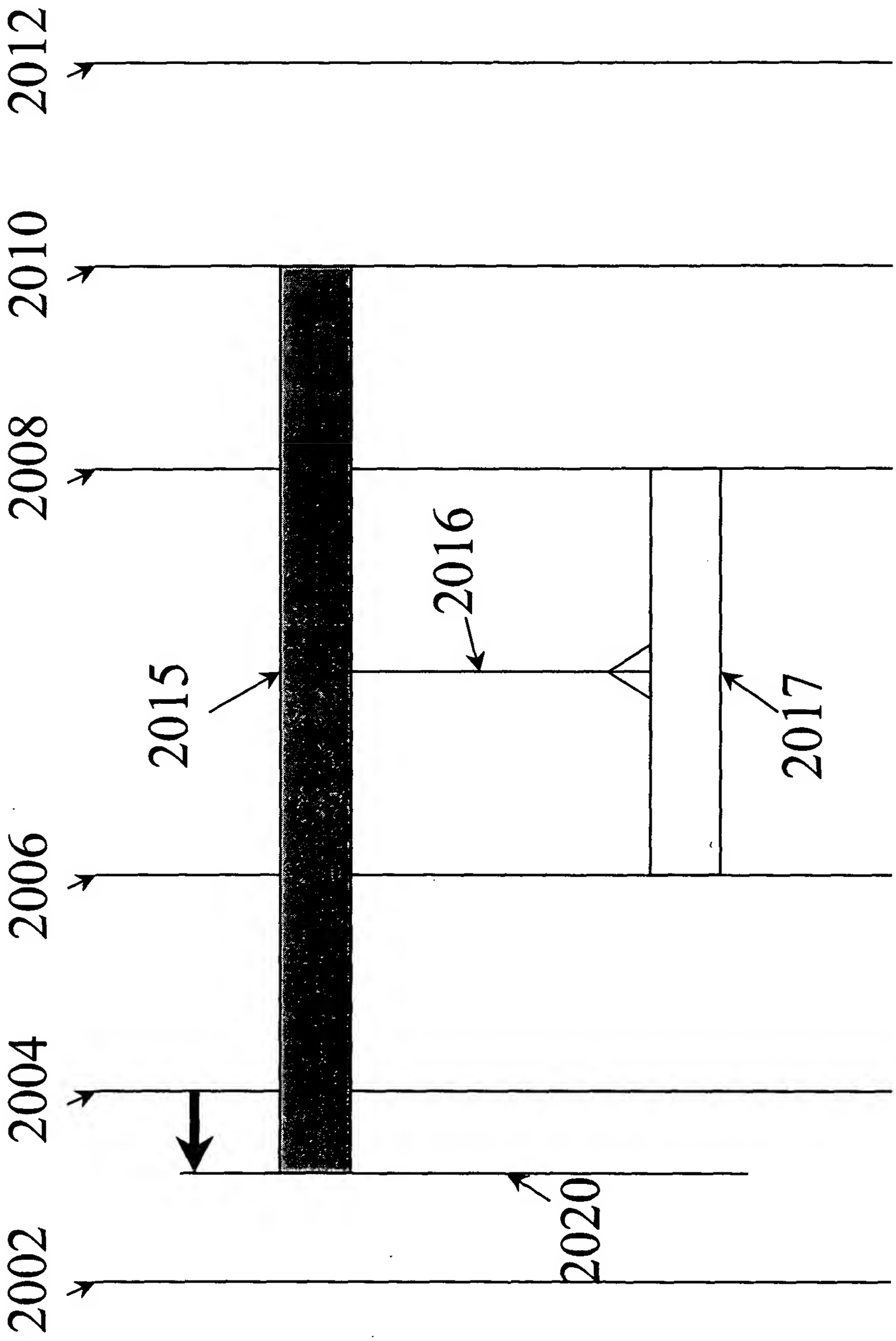


FIG. 20

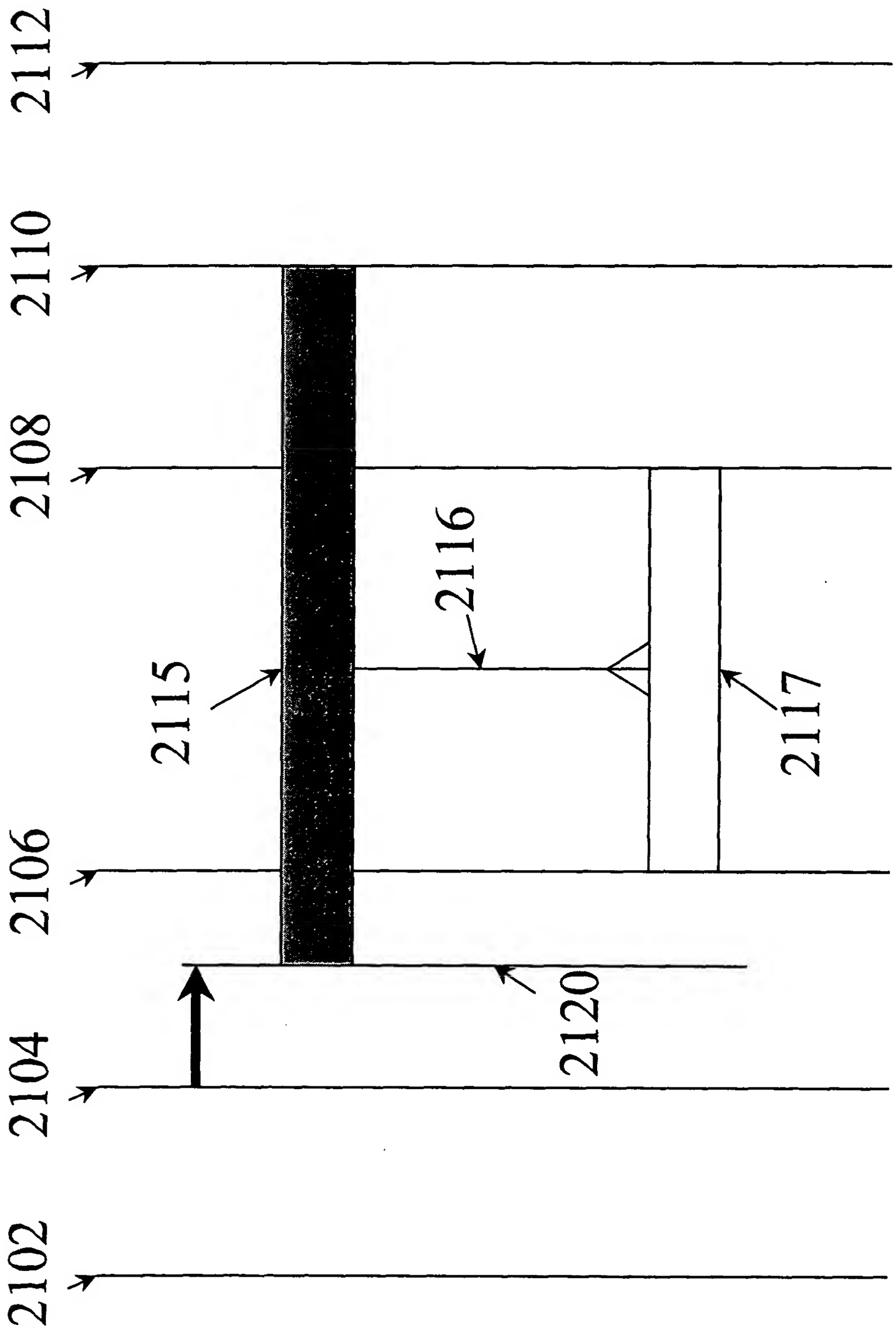


FIG. 21

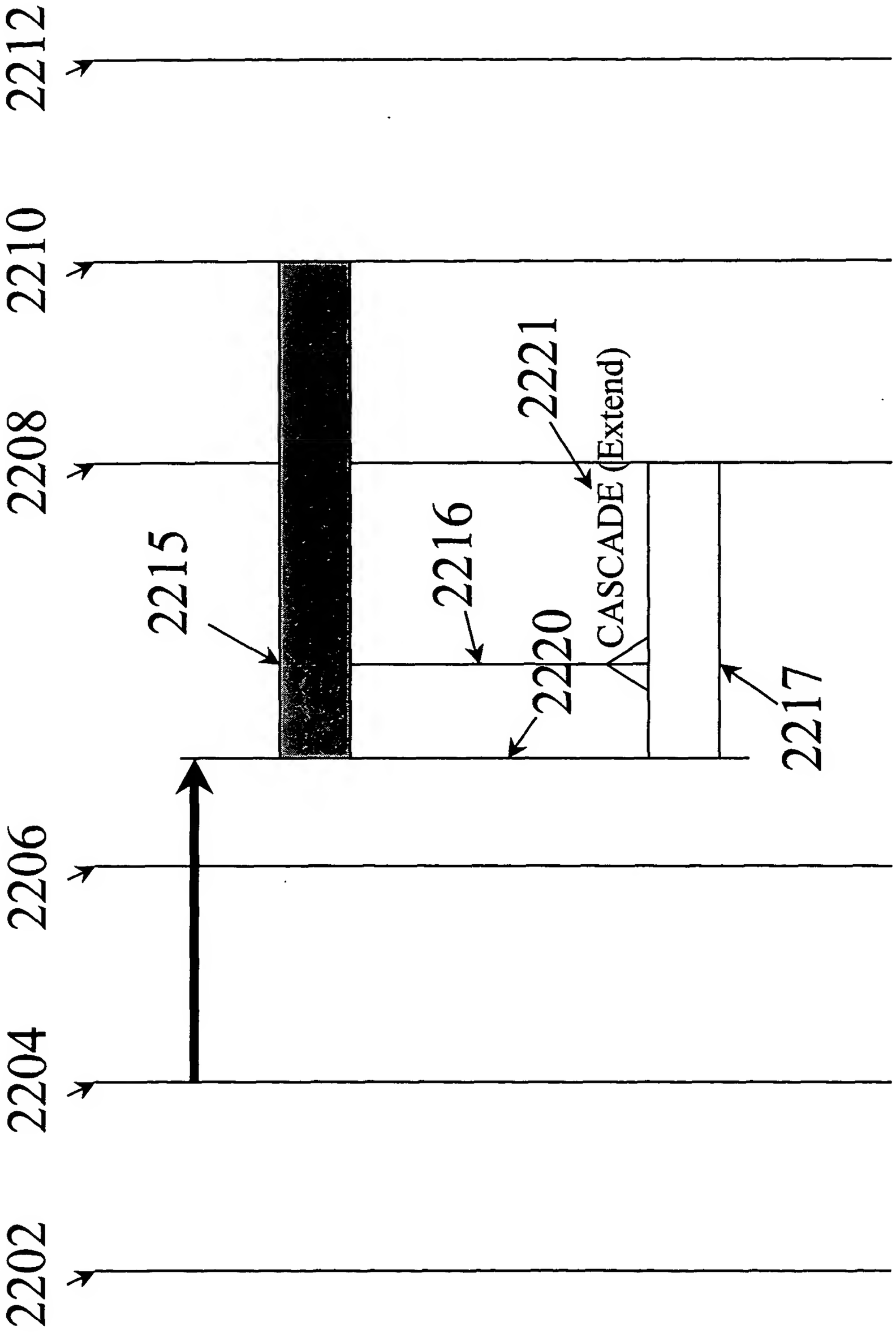

2212
2210
2208
2206
2204
2202
2215
2216
2220
2221
CASCADE (Extend)
2217

FIG. 22A

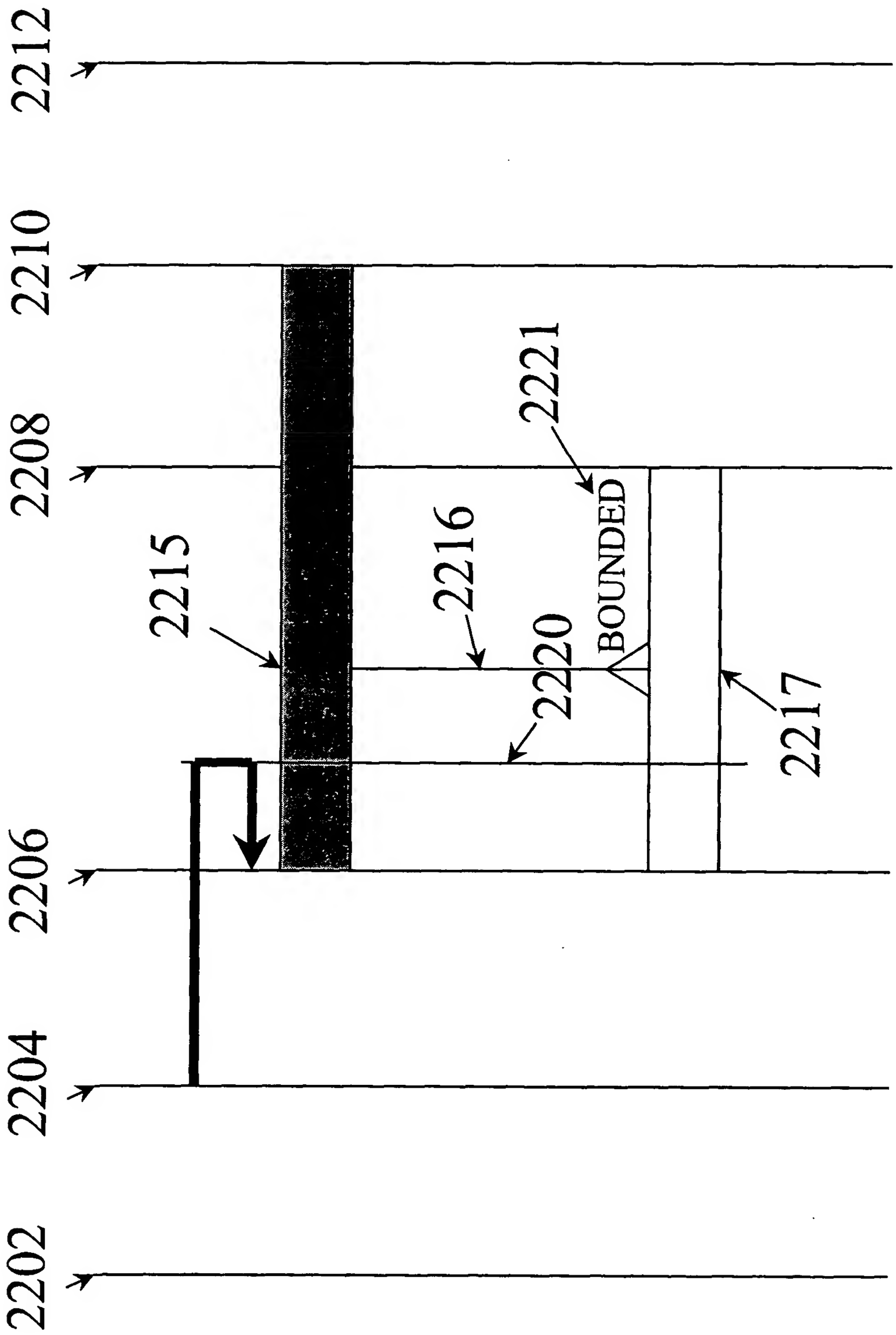

2212
2210
2208
2206
2204
2202
2215
2216
2221
BOUNDED
2220
2217

FIG. 22B

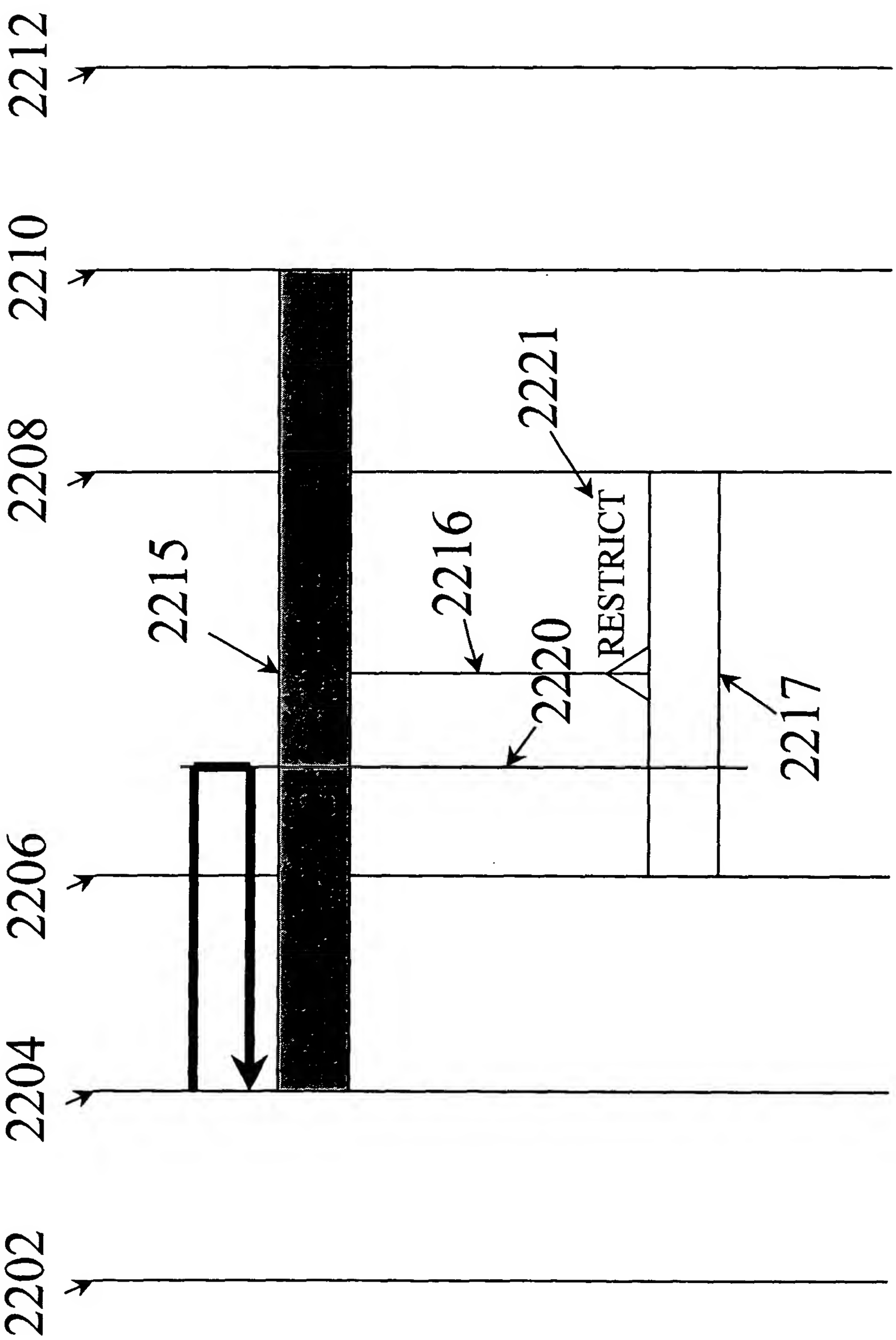

2212
2210
2208
2206
2204
2202
2215
2216
2220
2221
RESTRICT
2217

FIG. 22C

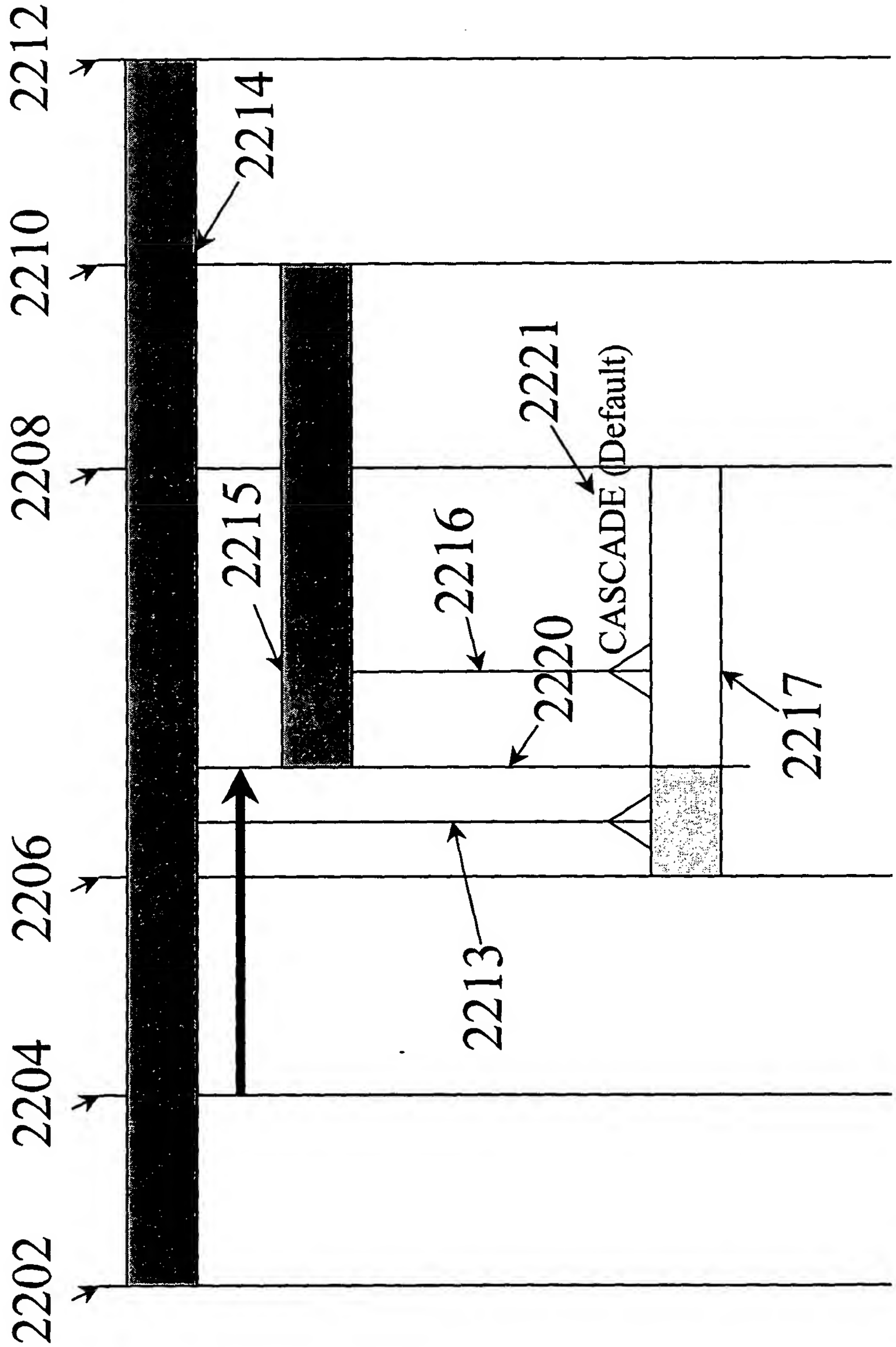

2212
2214
2210
2208
2221
CASCADE (Default)
2215
2216
2220
2217
2206
2213
2204
2202

FIG. 22D

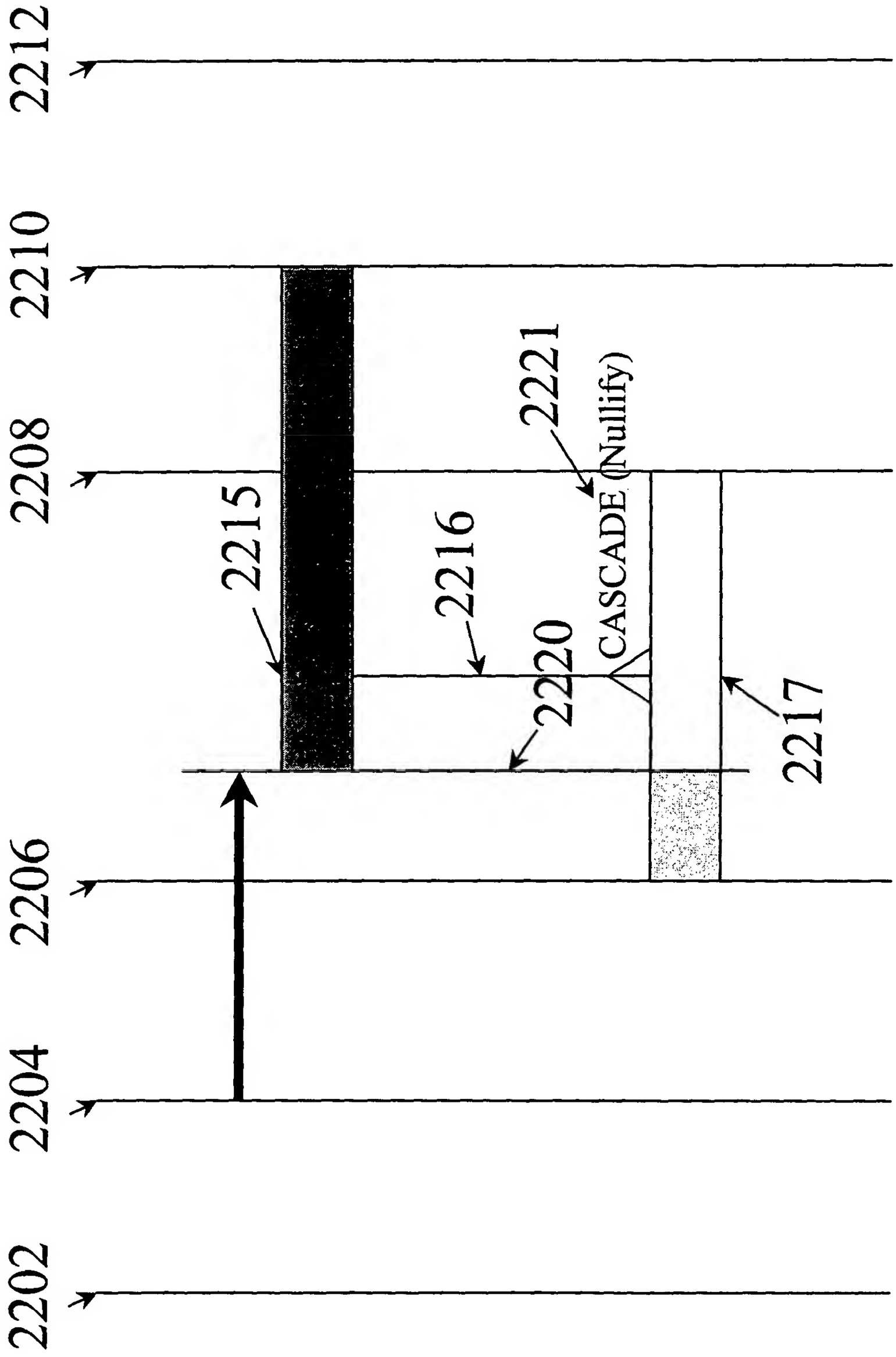

2212
2210
2208
2206
2204
2202
2215
2216
2220
2221
CASCADE (Nullify)
2217

FIG. 22E

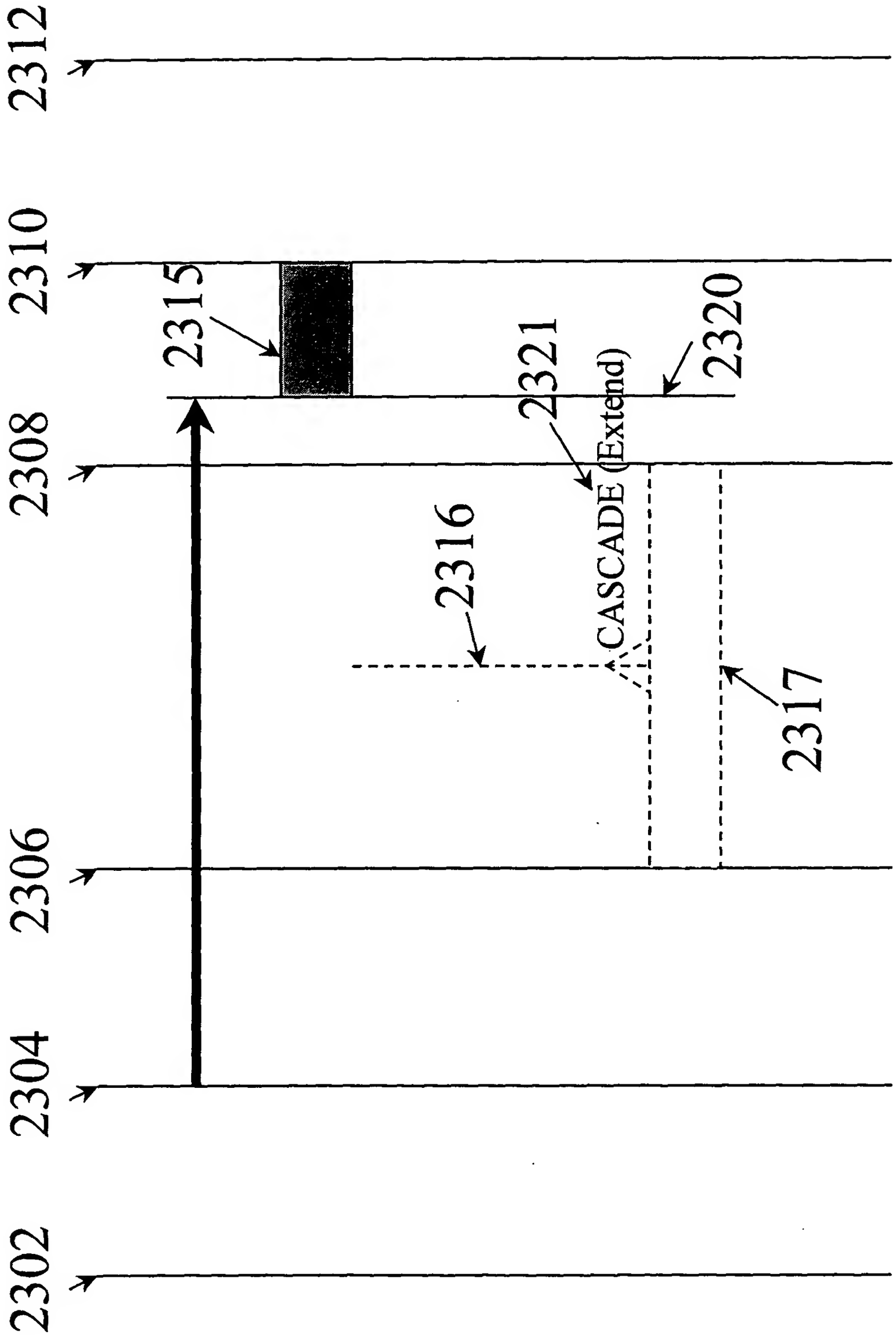

2312
2310
2308
2306
2304
2302
2315
2316
2317
2320
2321
CASCADE (Extend)

FIG. 23A

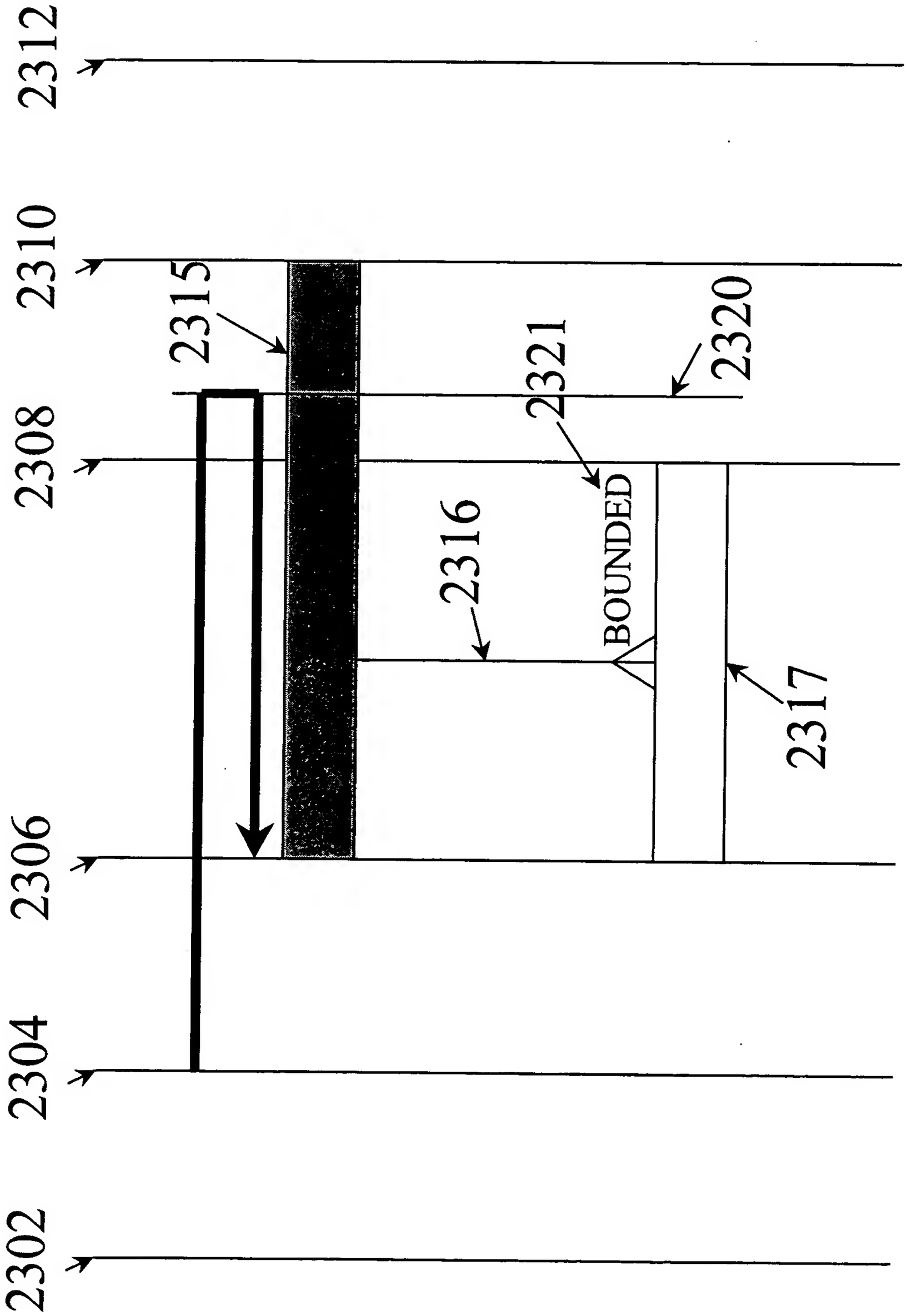

2312
2310
2315
2308
2321
2320
2316
BOUNDED
2306
2317
2304
2302

FIG. 23B

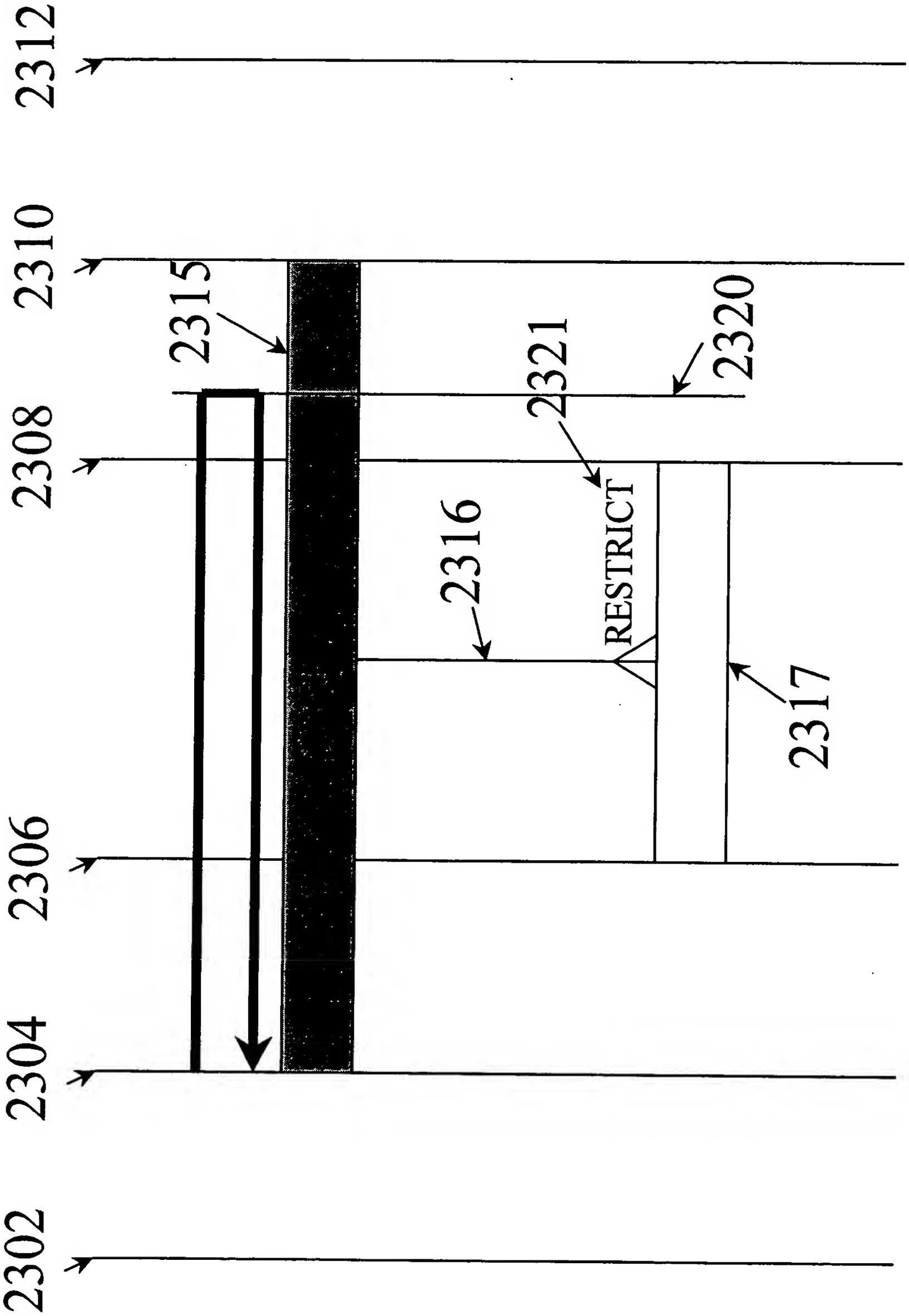

2312
2310
2315
2308
2321
2320
2316
RESTRICT
2306
2317
2304
2302

FIG. 23C

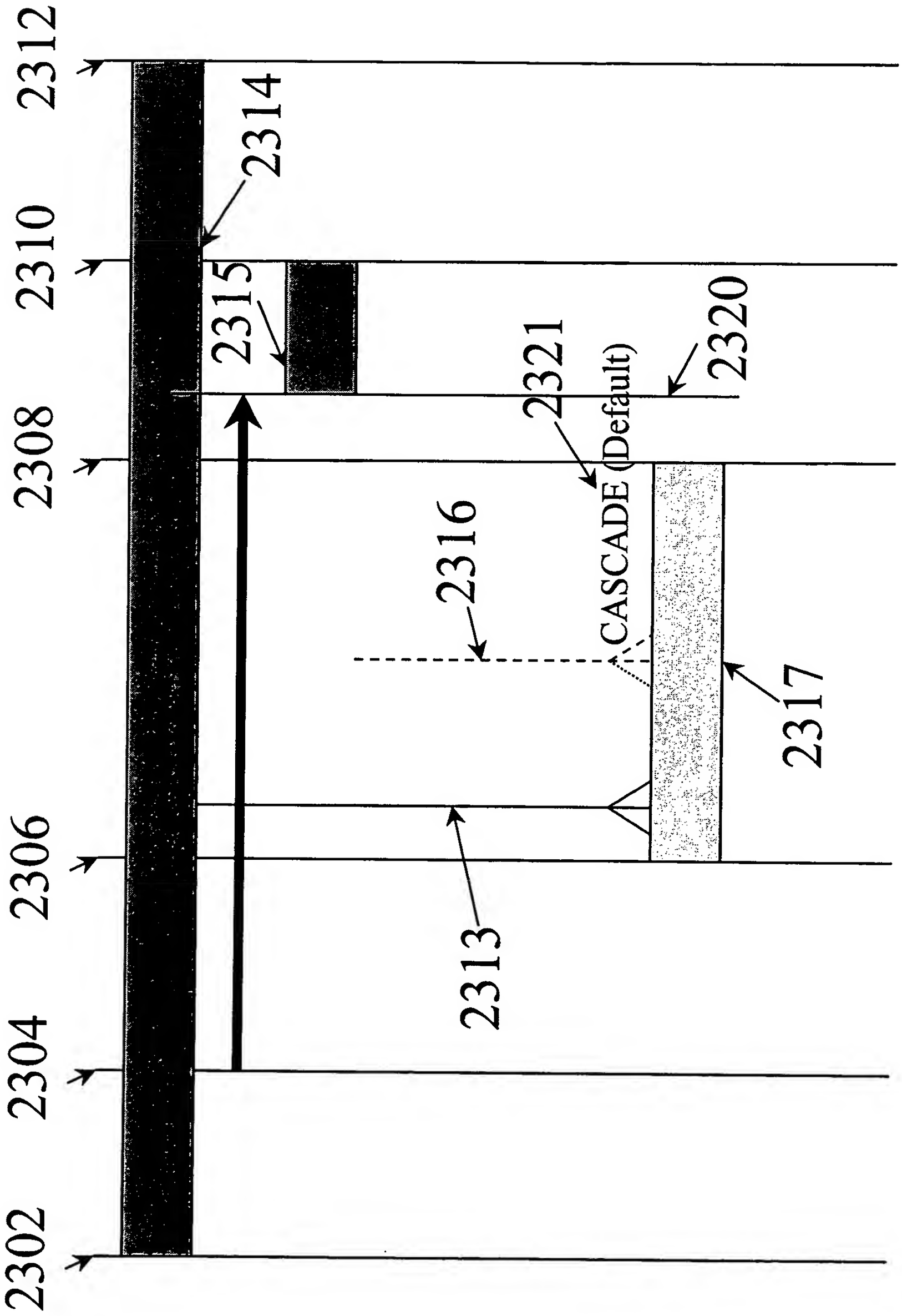

2312
2310
2308
2306
2304
2302
2314
2315
2316
2317
2320
2321
2313
CASCADE (Default)

FIG. 23D

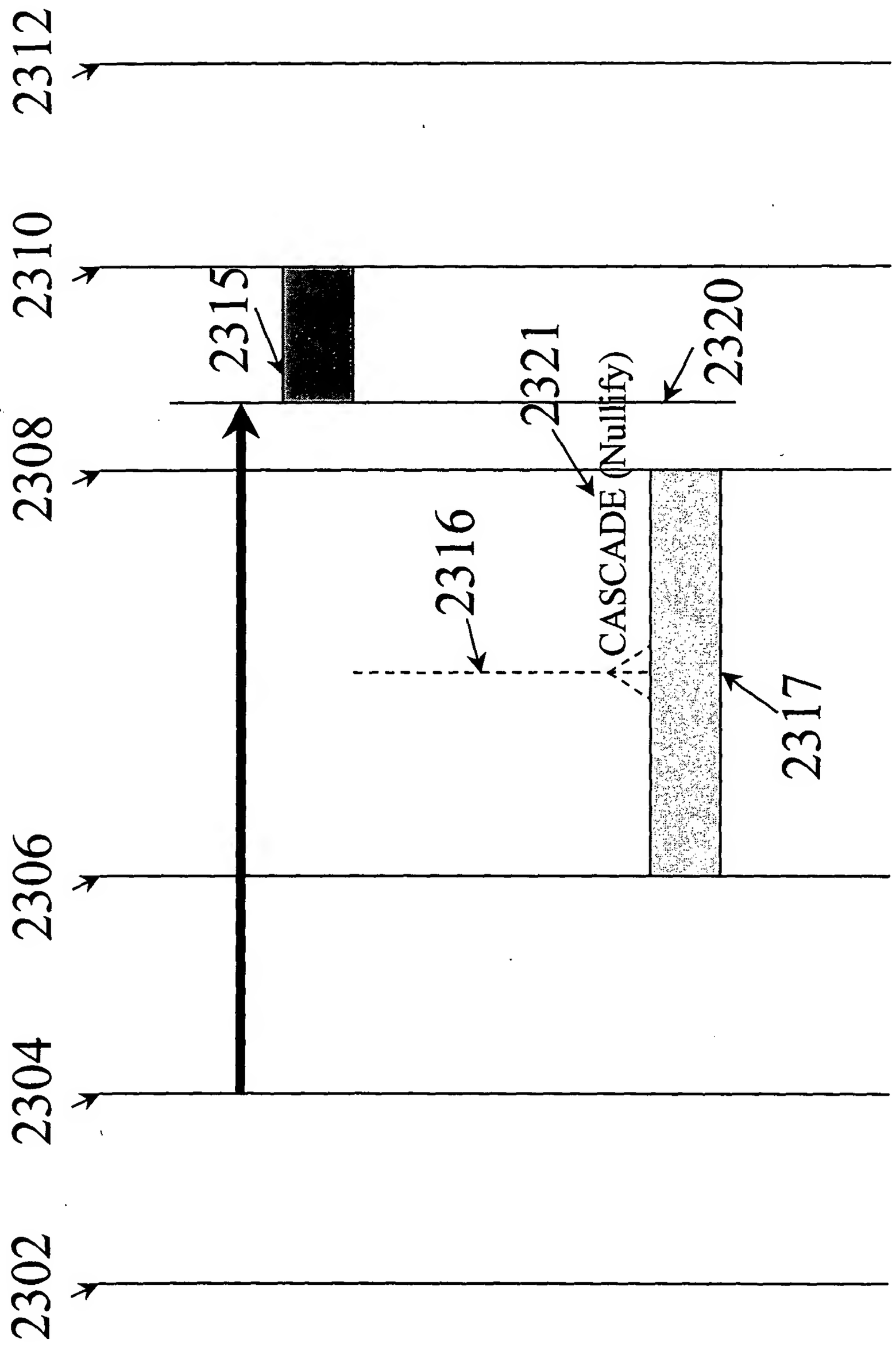

2312
2310
2315
2321
(Nullify)
2320
2308
2316
CASCADE
2317
2306
2304
2302

FIG. 23E

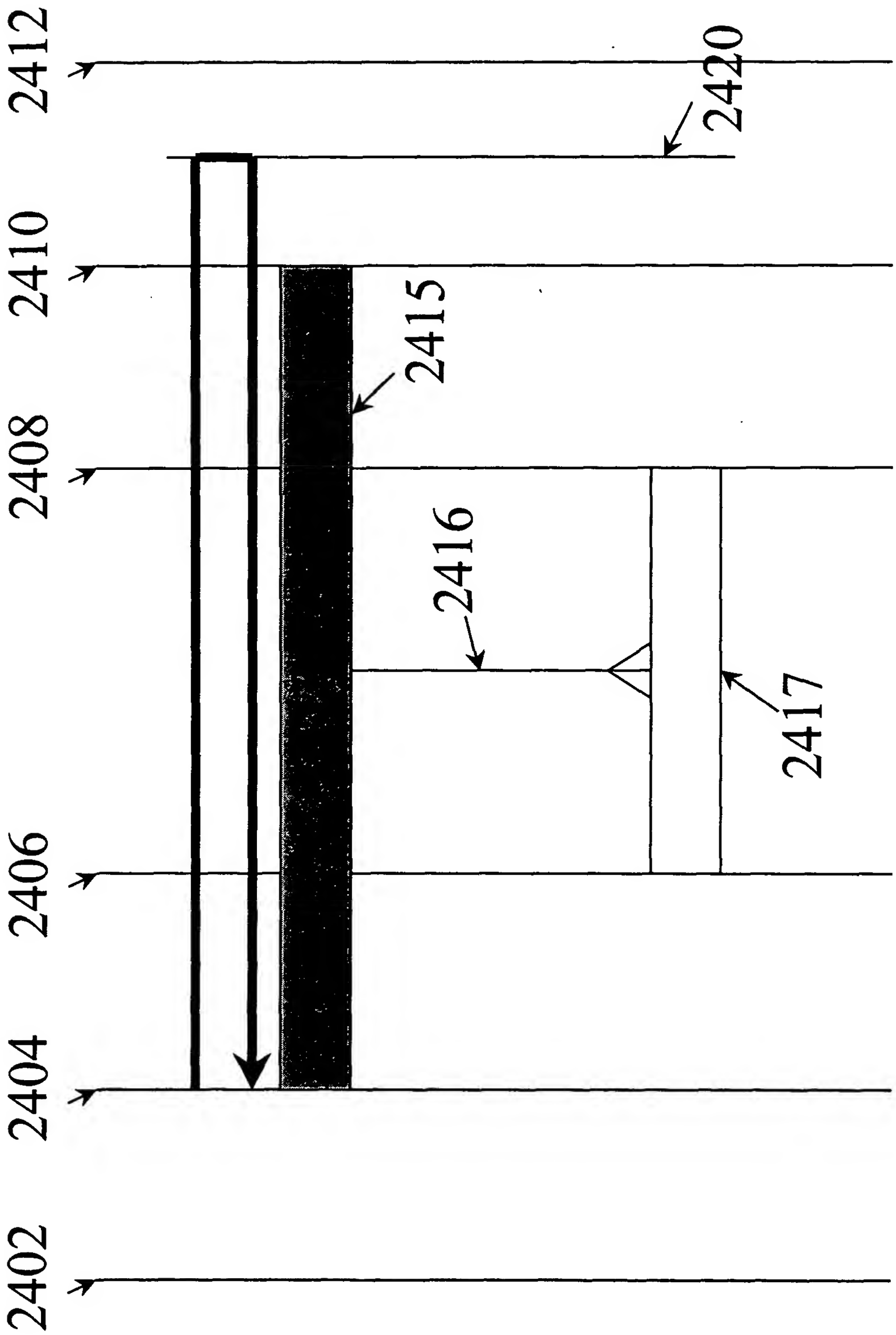


FIG. 24

	Action	Rule	This Invention	Prior Art	
	Insert	cascade (extend)	yes	no equivalent	
		bounded	yes	no equivalent	
		restrict	yes	no equivalent	
		cascade (default)	yes	no equivalent	
		cascade (nullify)	yes	no equivalent	
	Alter Insert Back	cascade (extend)	yes	no equivalent	
		bounded	yes	no equivalent	
		restrict	yes	no equivalent	
		cascade (default)	yes	no equivalent	
		cascade (nullify)	yes	no equivalent	
	Alter Insert Forward	cascade (extend)	yes	no equivalent	
		bounded	yes	no equivalent	
		restrict	yes	no equivalent	
		cascade (default)	yes	no equivalent	
		cascade (nullify)	yes	no equivalent	
	Update	cascade (extend)	yes	no	
		bounded	yes	no equivalent	
		restrict	yes	part (via server side code)	
		cascade (default)	yes	no	
		cascade (nullify)	yes	no	
	Delete	cascade (extend)	yes	yes	
		bounded	yes	no equivalent	
		restrict	yes	yes	
		cascade (default)	yes	no	
		cascade (nullify)	yes	no	
	Alter Delete Back	cascade (extend)	yes	no equivalent	
		bounded	yes	no equivalent	
		restrict	yes	no equivalent	
		cascade (default)	yes	no equivalent	
		cascade (nullify)	yes	no equivalent	
	Alter Delete Forward	cascade (extend)	yes	no equivalent	
		bounded	yes	no equivalent	
		restrict	yes	no equivalent	
		cascade (default)	yes	no equivalent	
		cascade (nullify)	yes	no equivalent	

FIG. 25

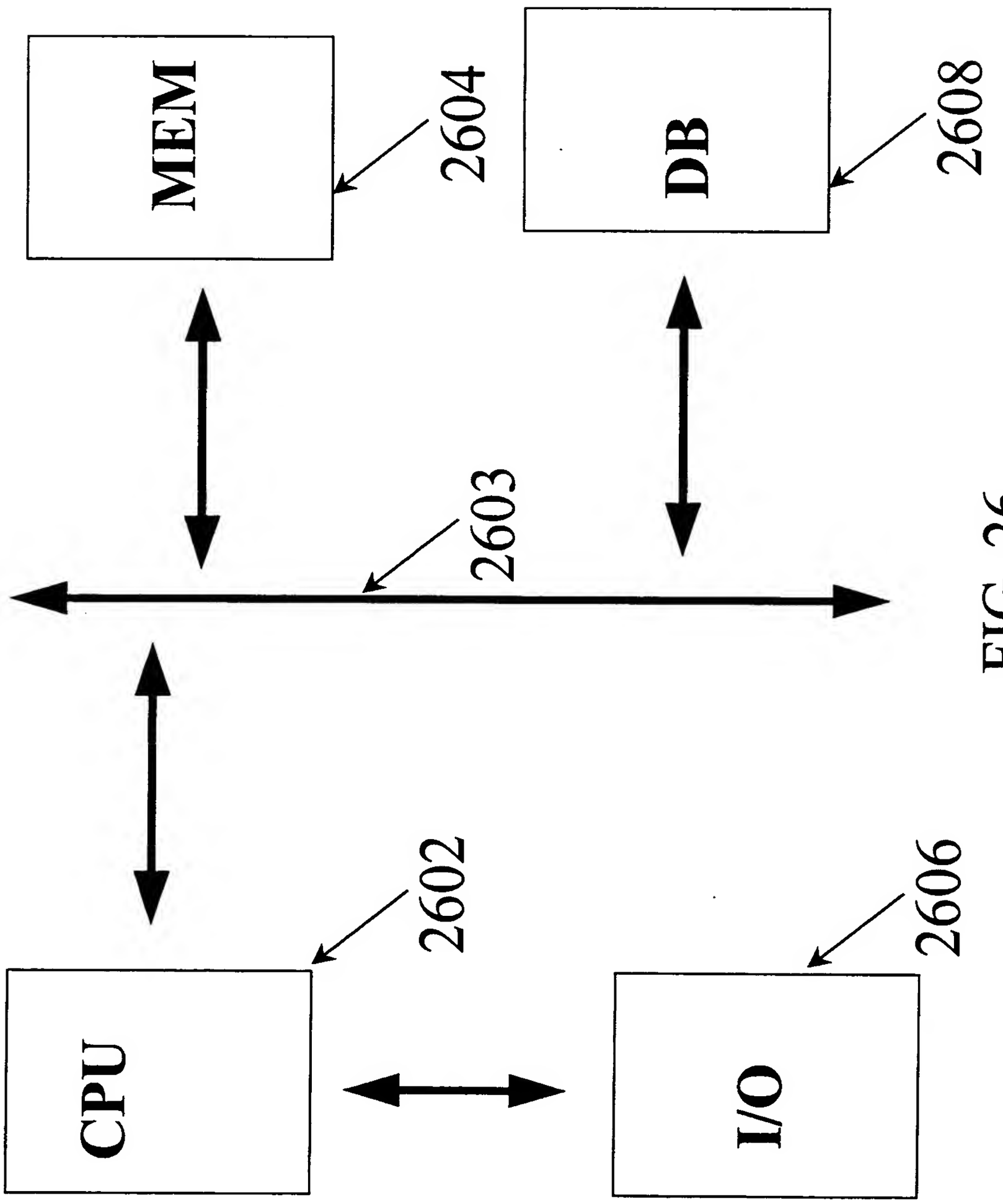


FIG. 26

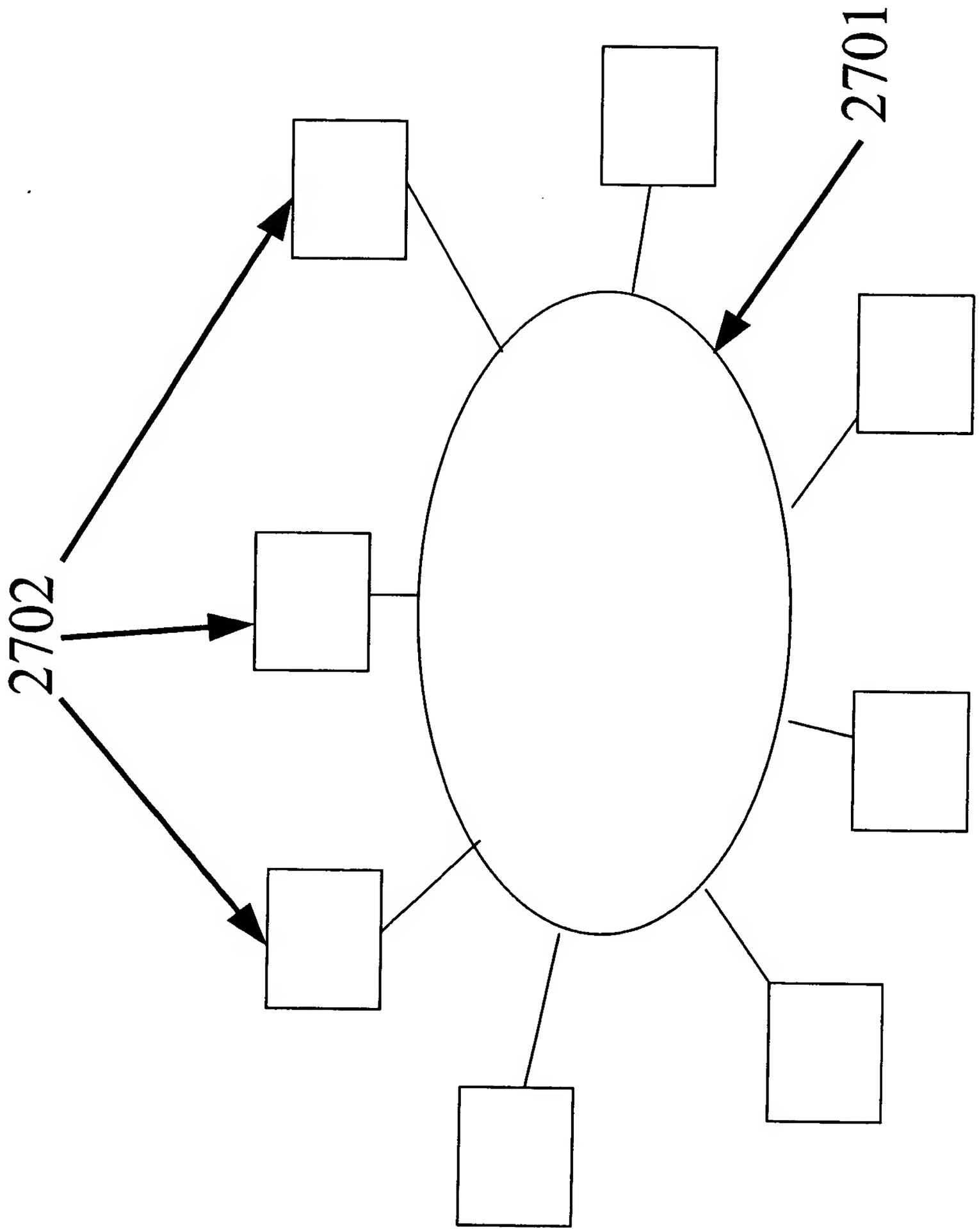


FIG. 27

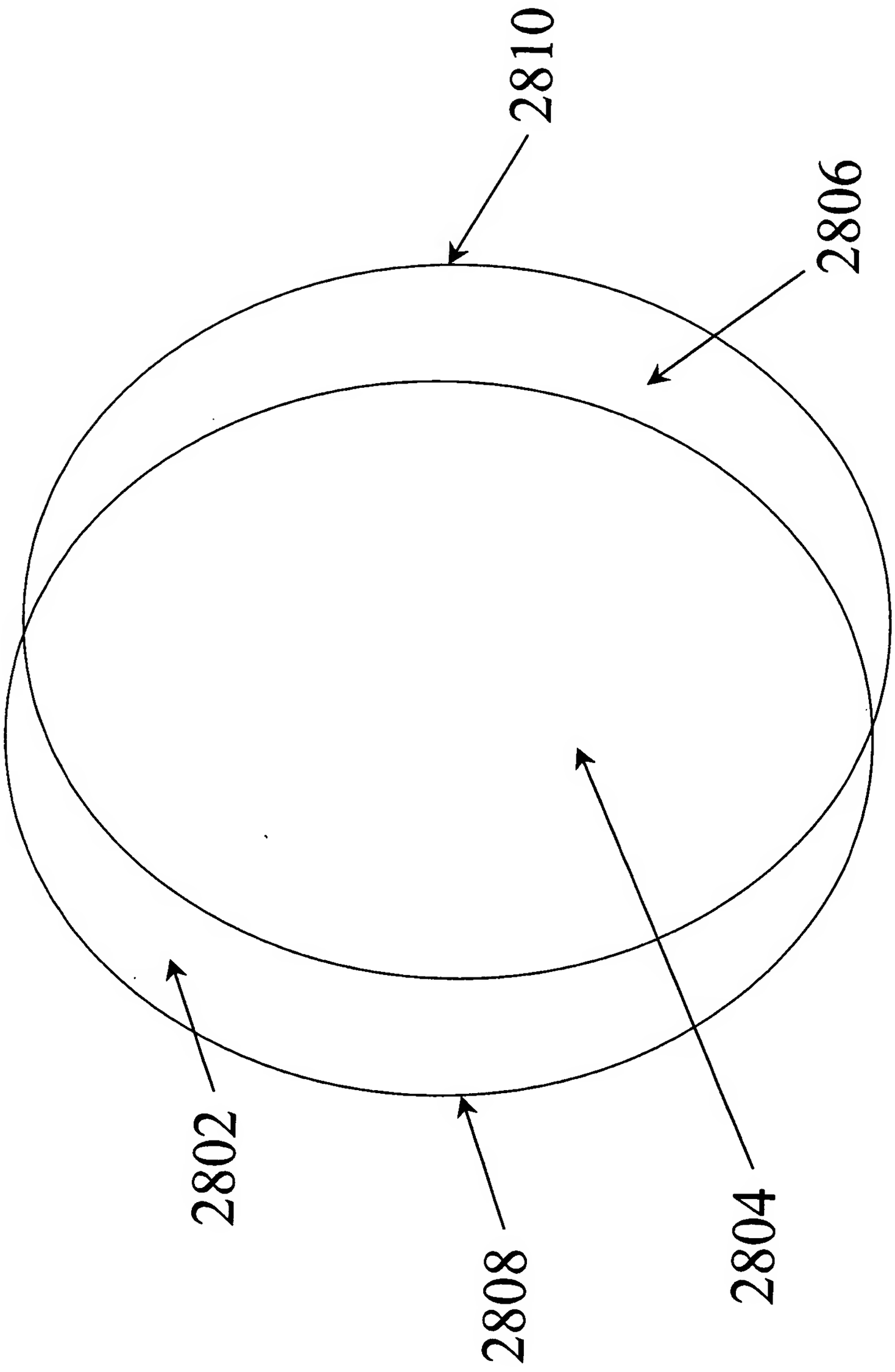


FIG. 28

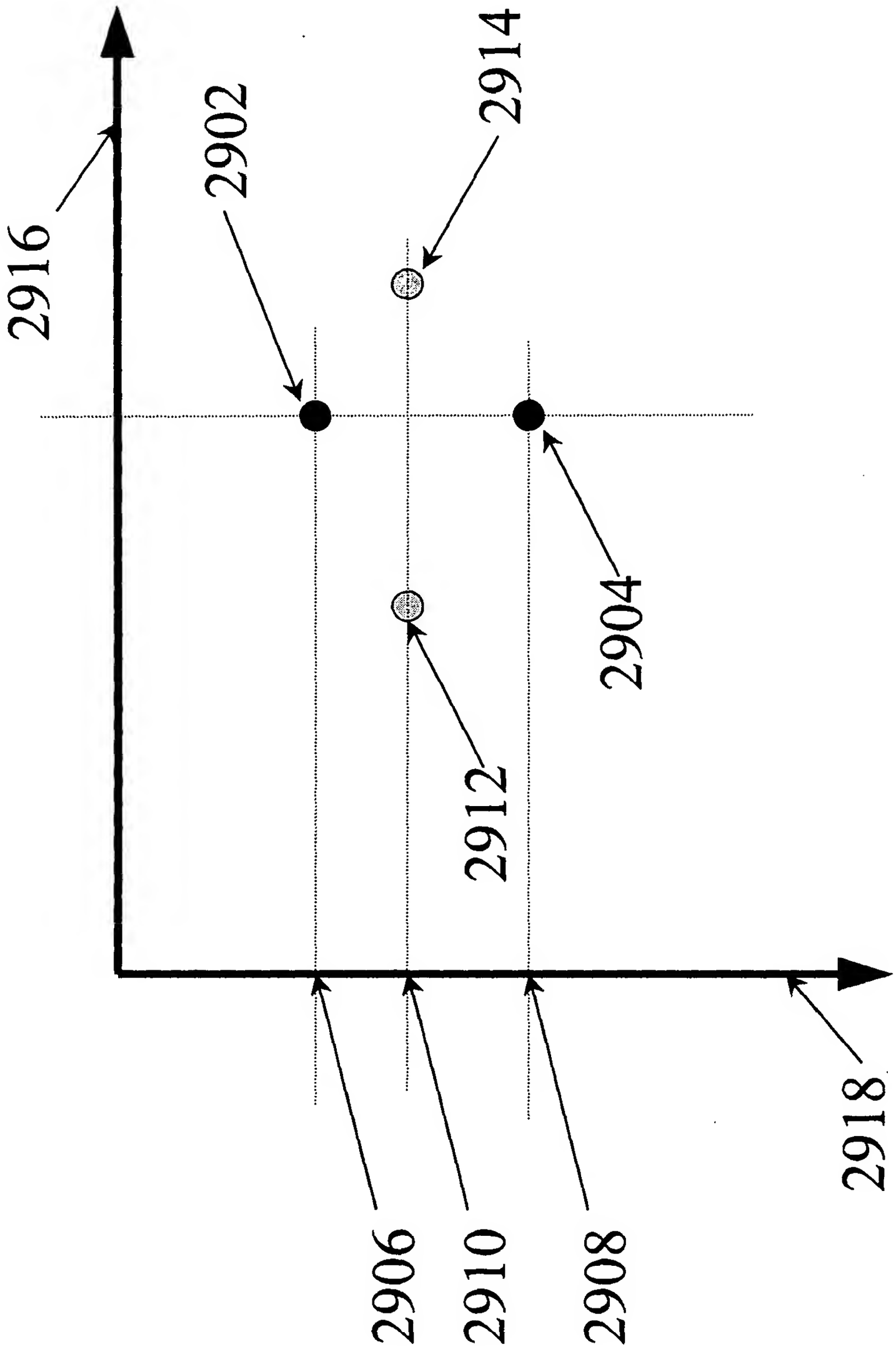


FIG. 29

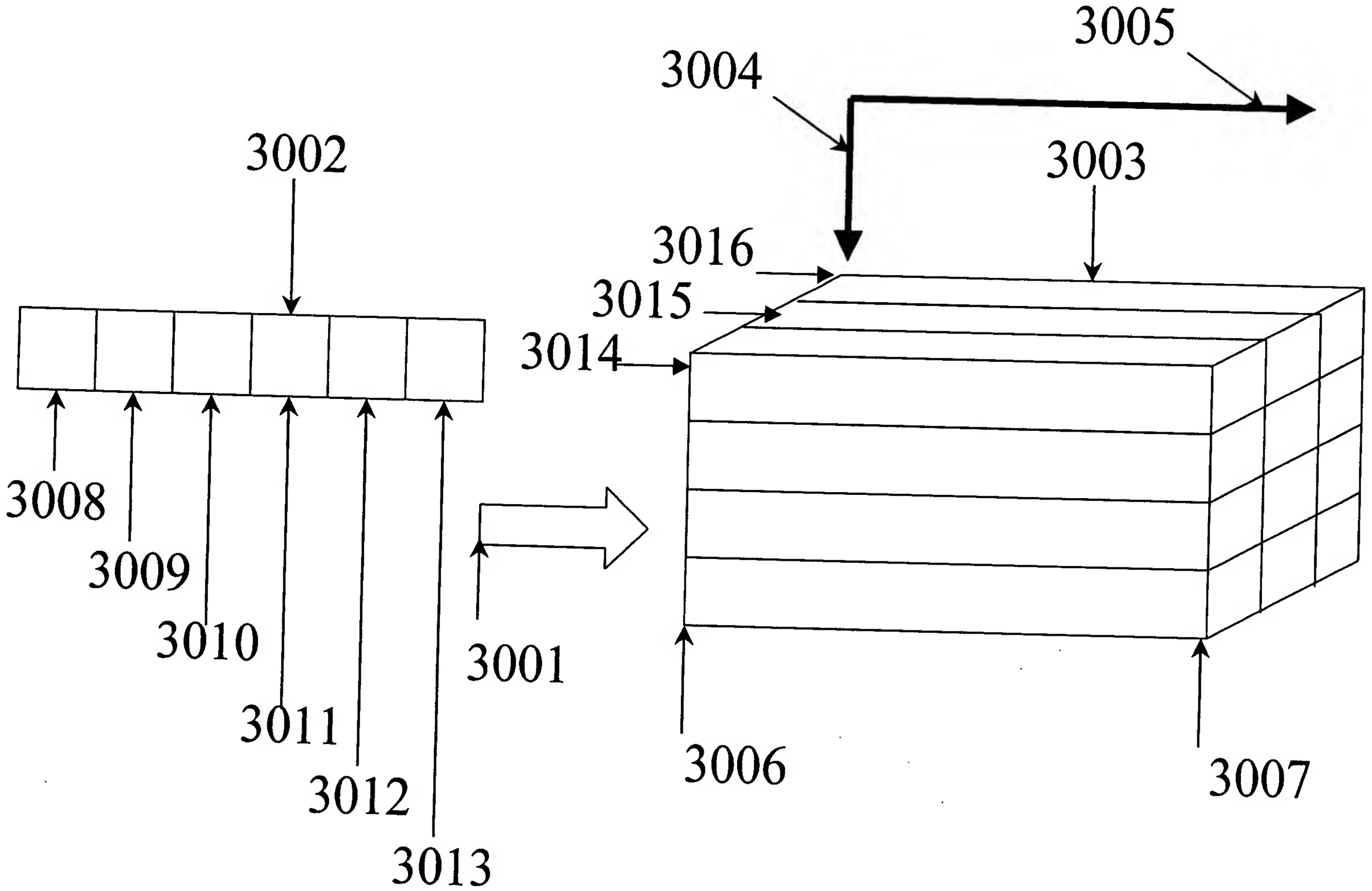

3005
3004
3002
3003
3016
3015
3014
3008
3009
3010
3011
3012
3013
3001
3006
3007

FIG. 30

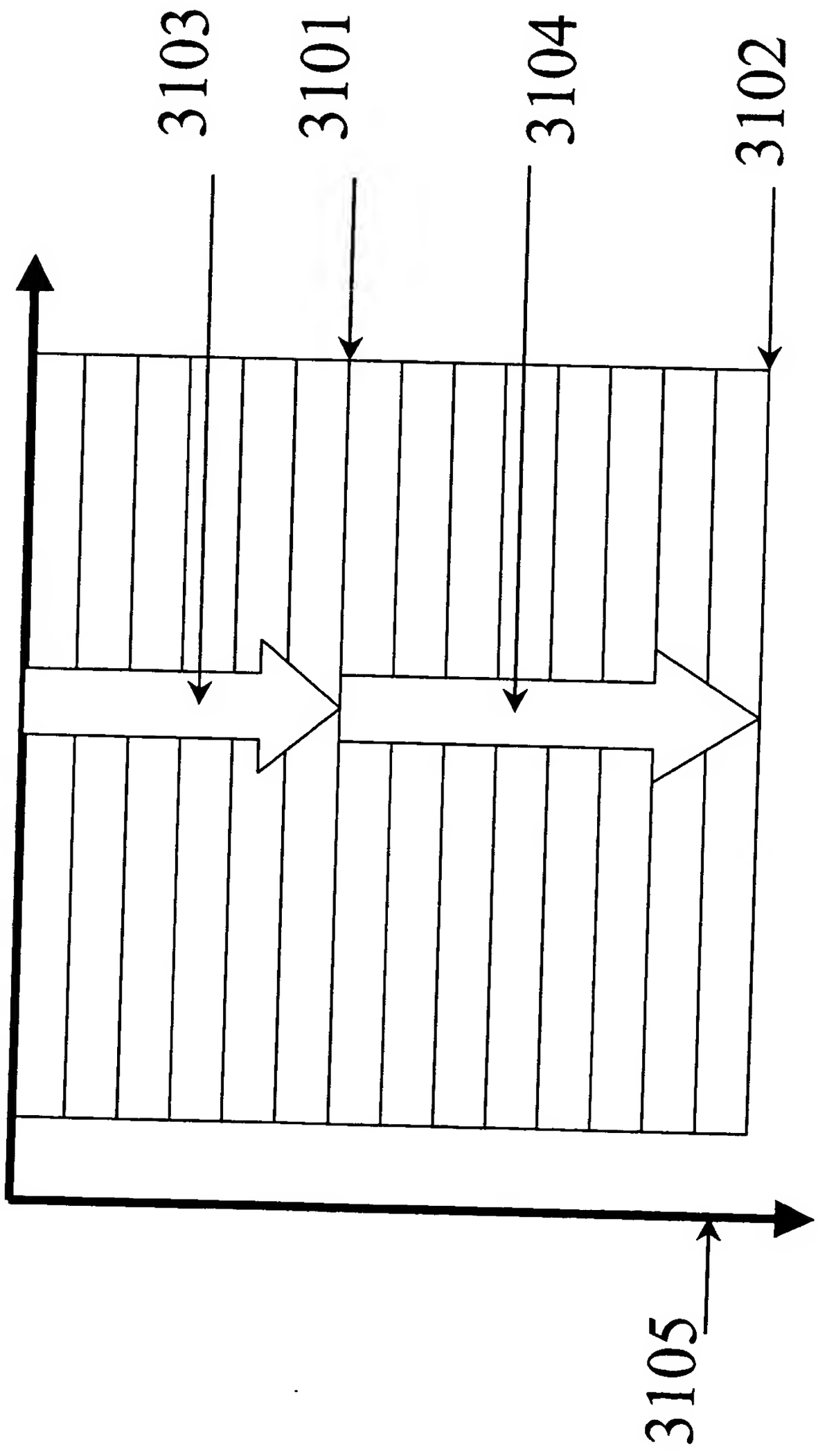


FIG. 31

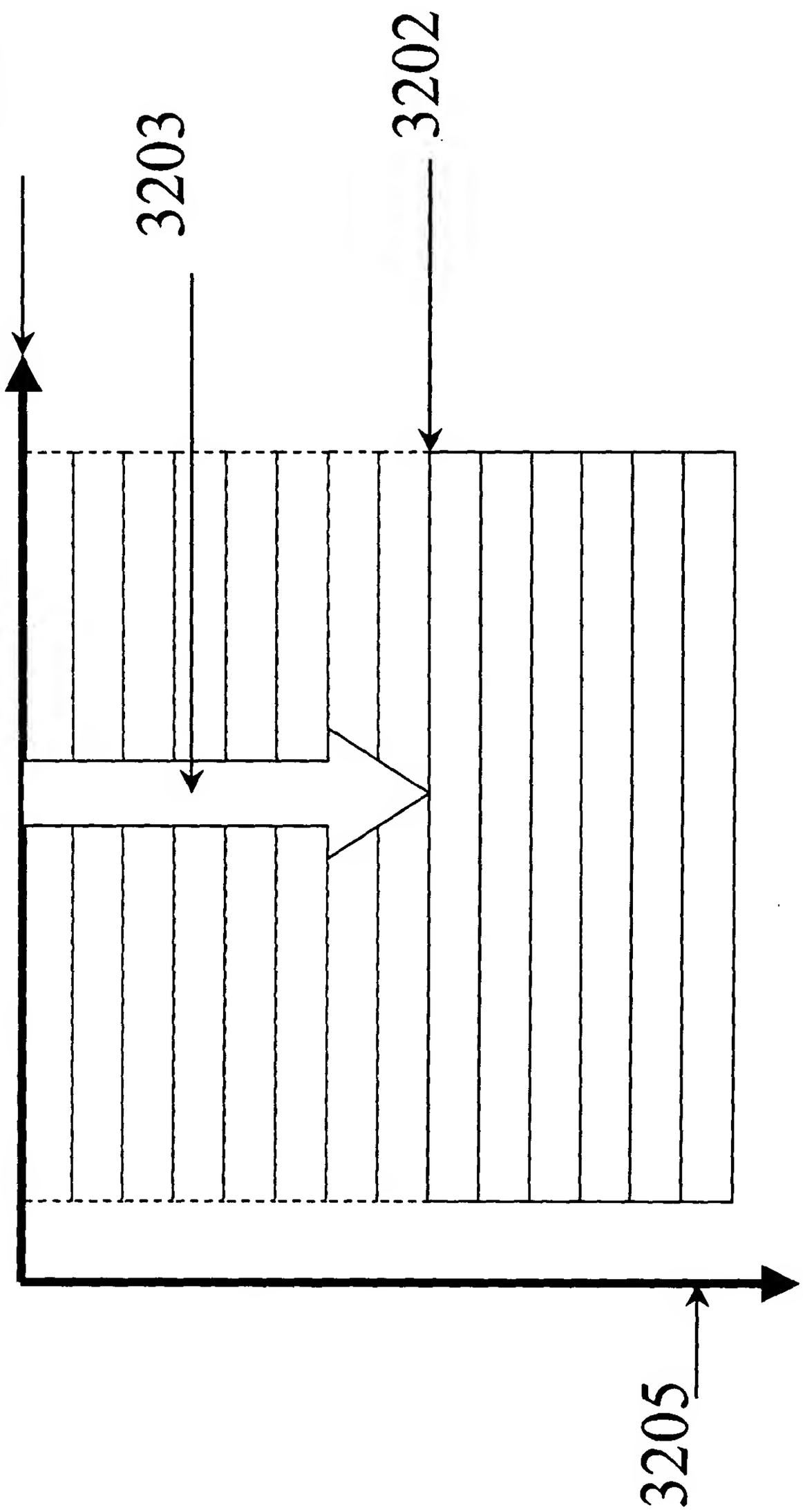


FIG. 32

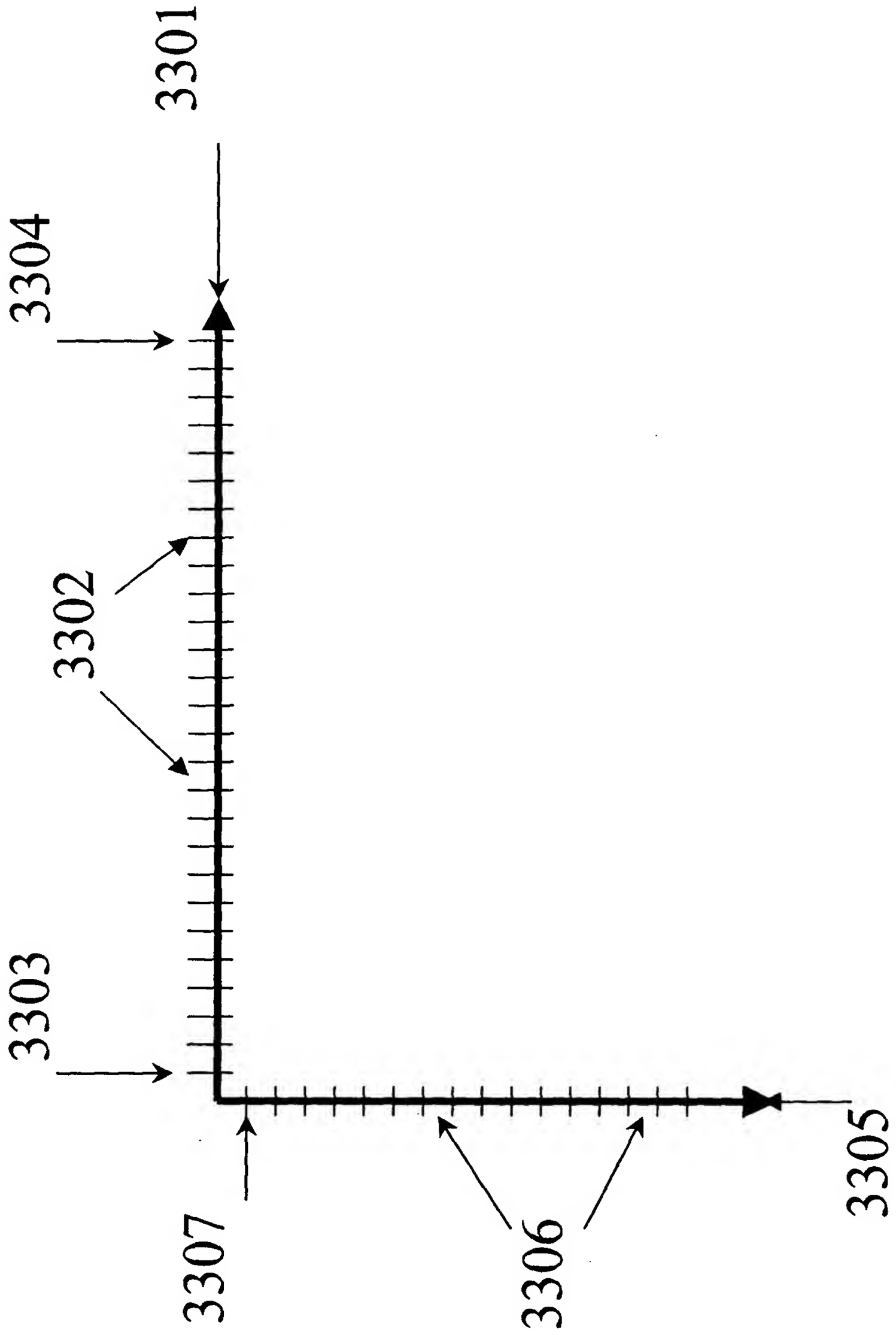


FIG. 33

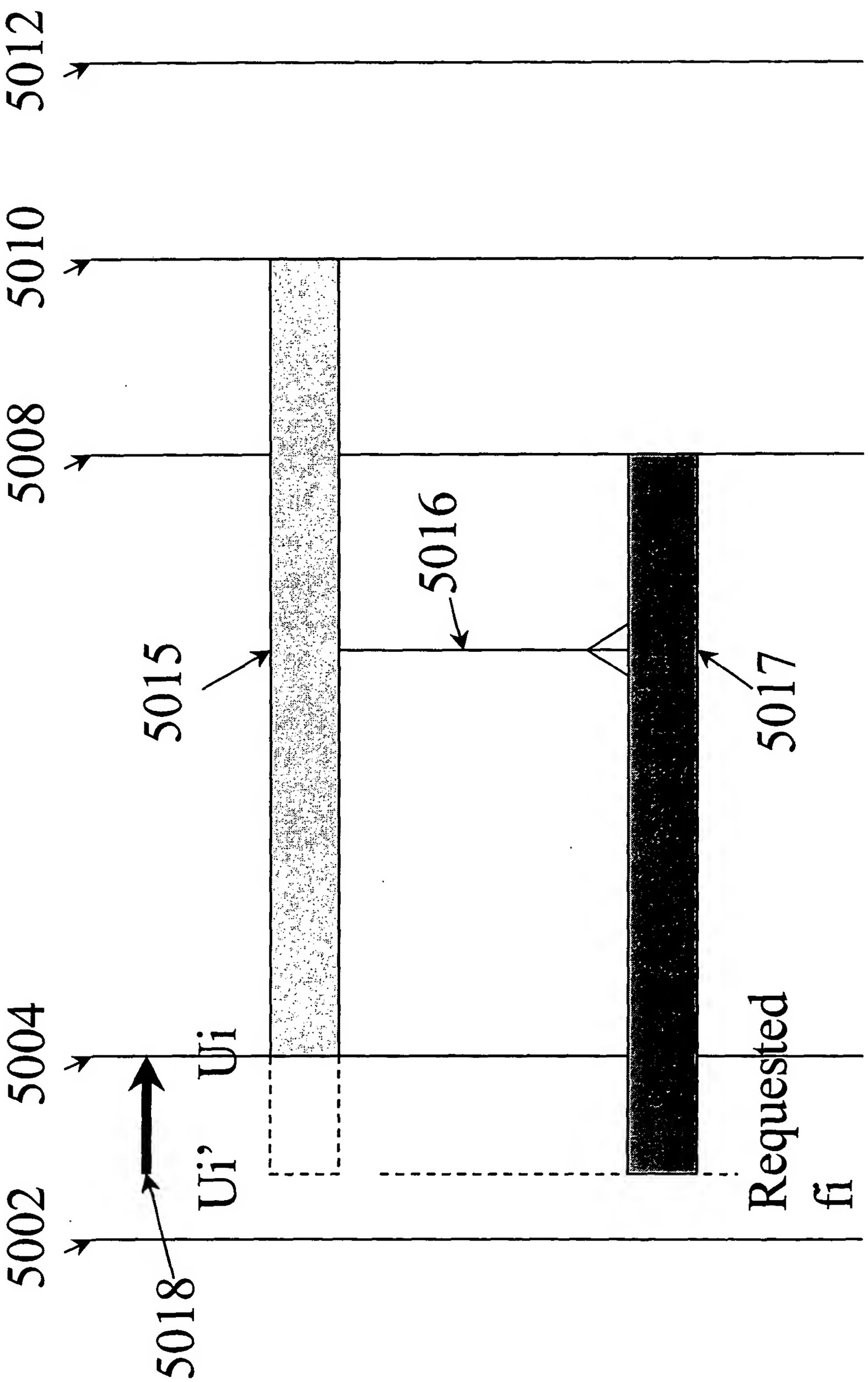

5012
5010
5008
5016
5015
5017
5004
Ui
Ui'
Requested
fi
5002
5018

FIG. 50

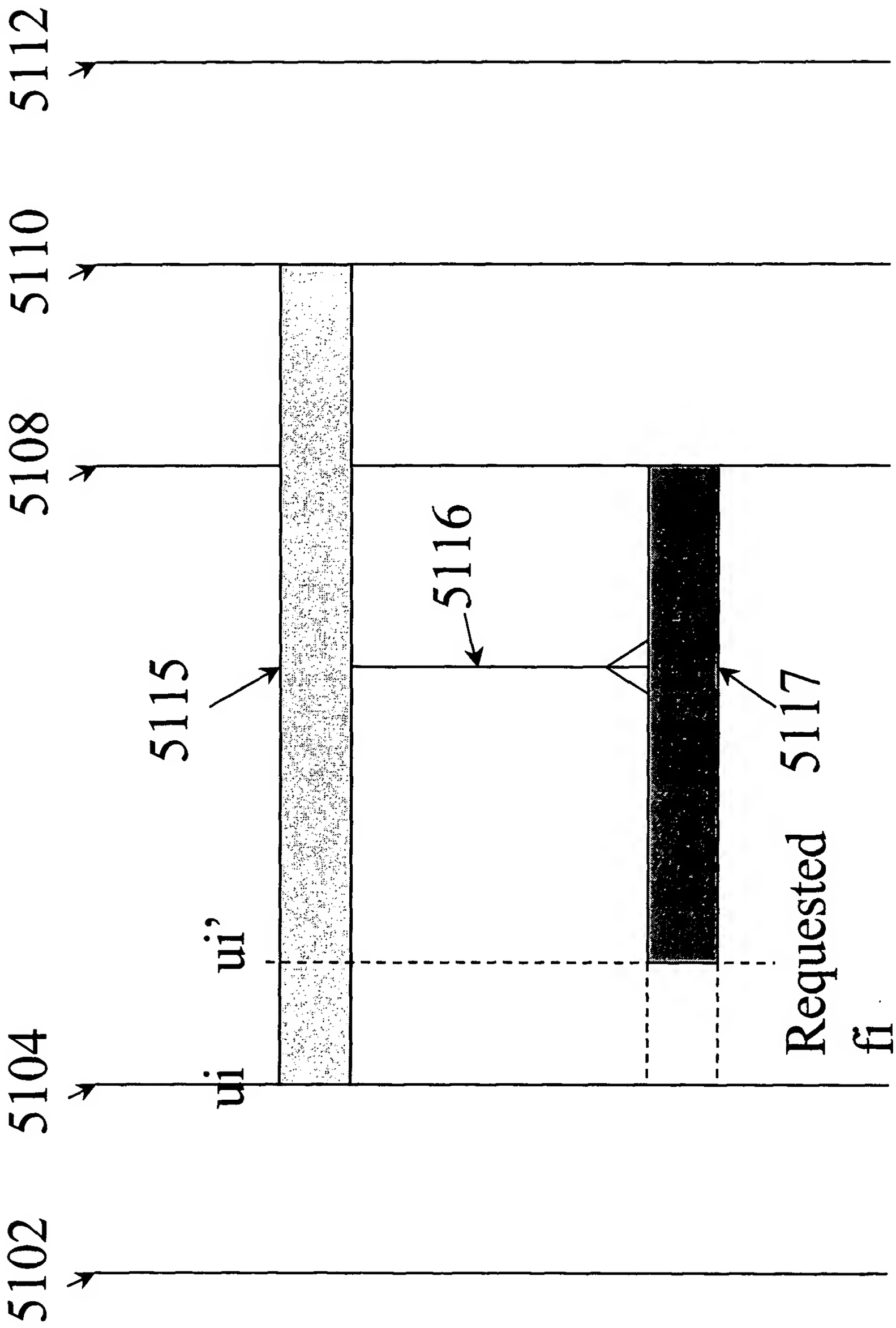


FIG. 51

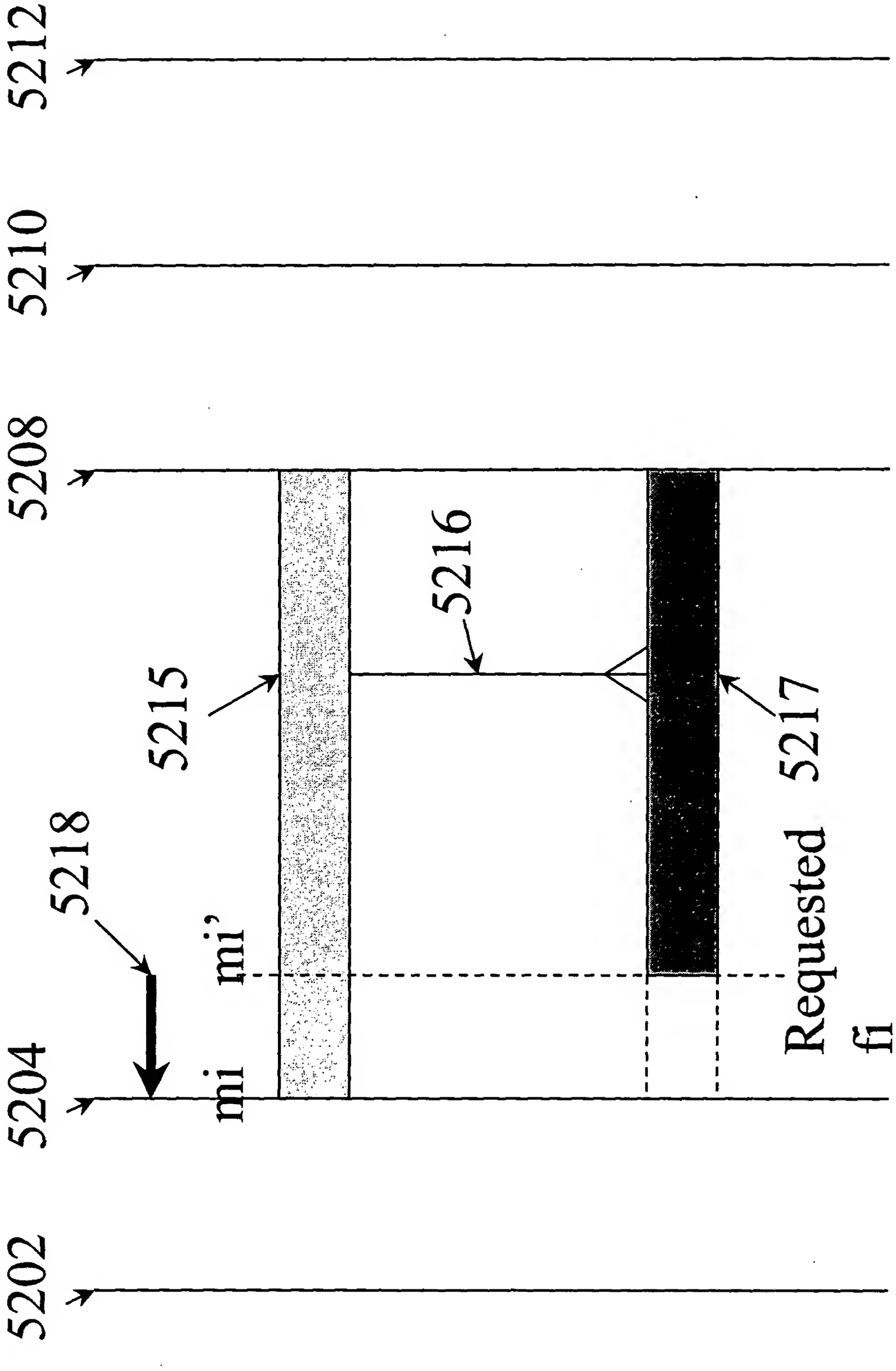

5212
5210
5208
5216
5215
5218
mi'
5217
Requested
fi
5204
mi
5202

FIG. 52

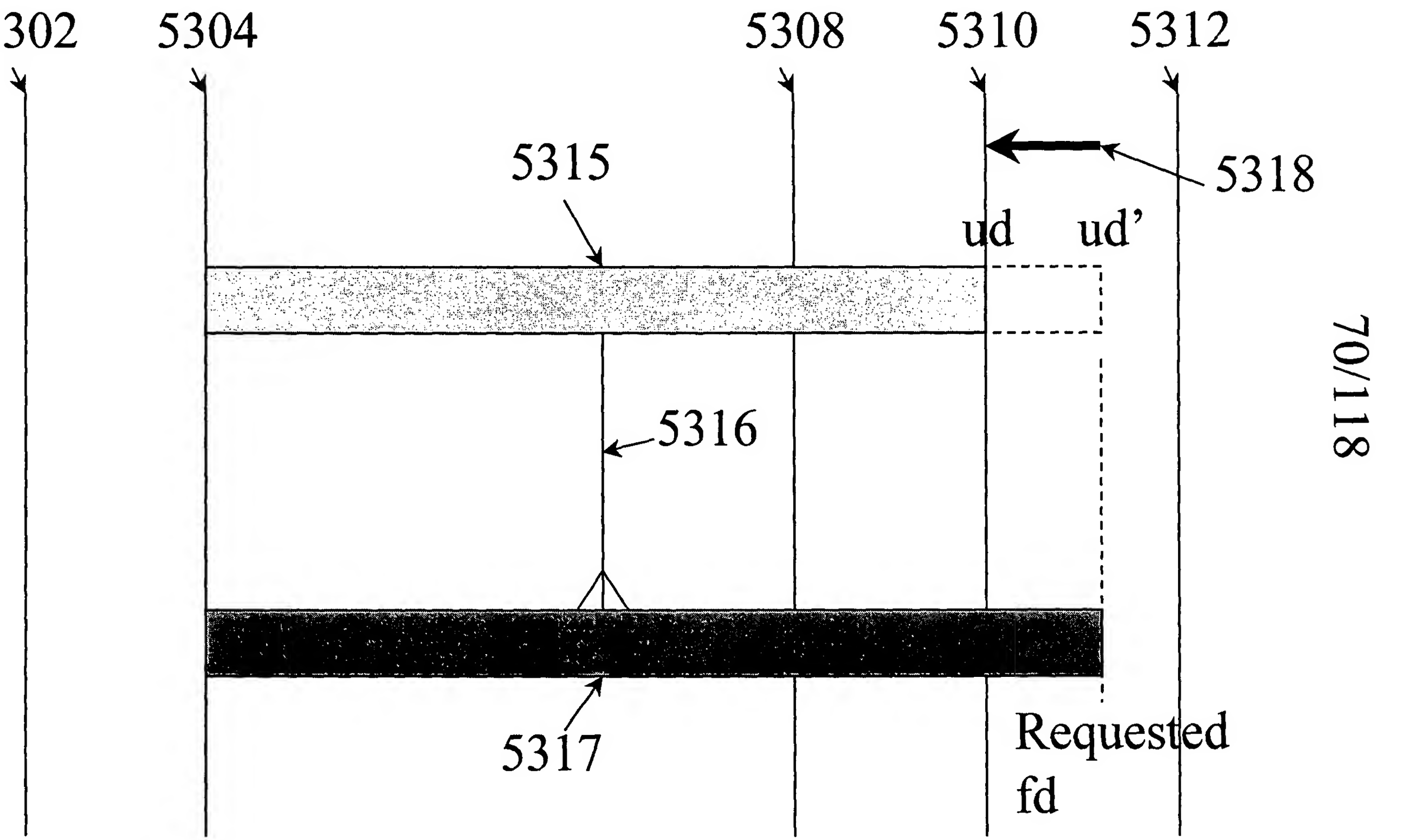

5302
5304
5308
5310
5312
5315
5318
ud
ud'
5316
5317
Requested
fd

FIG. 53

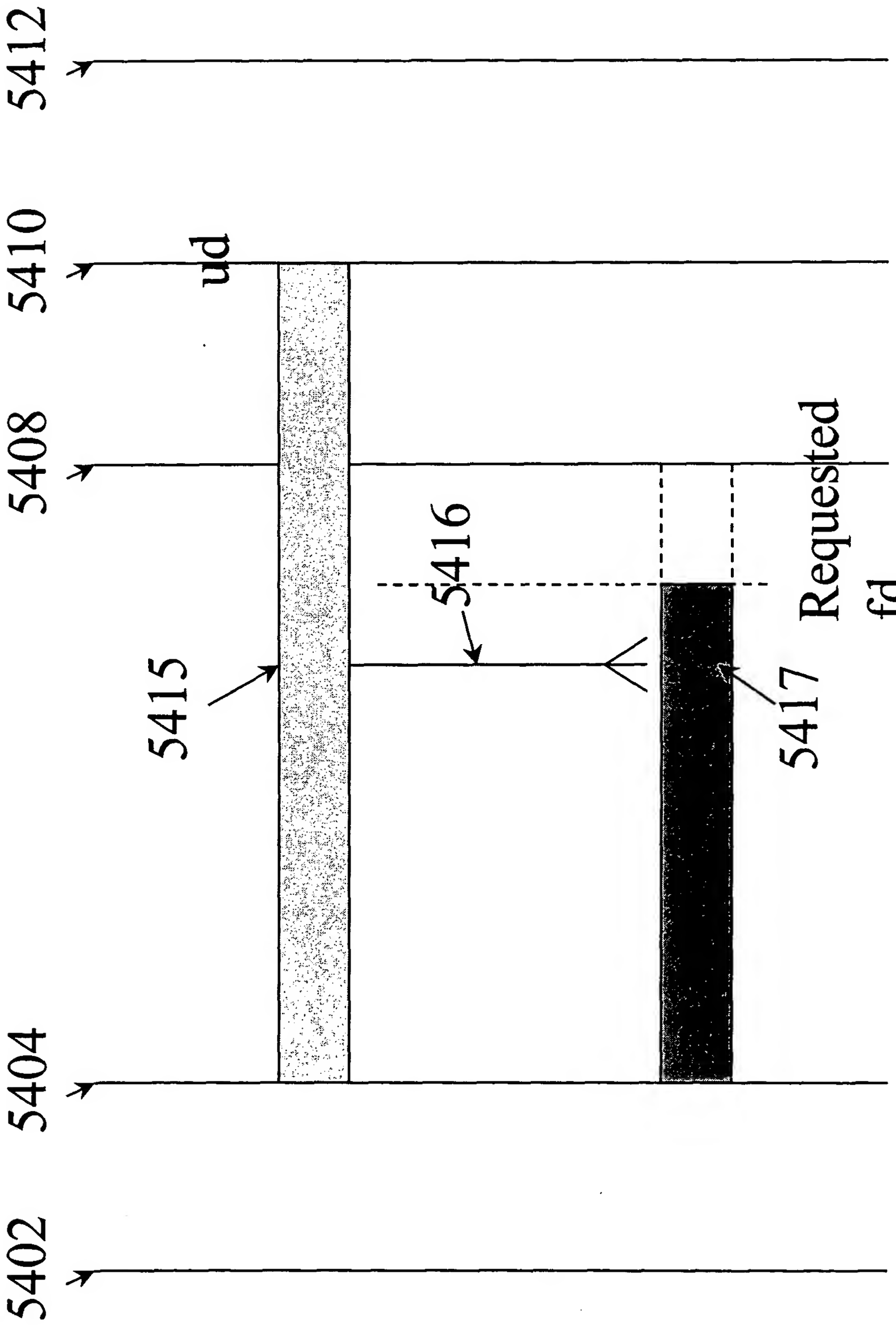


FIG. 54

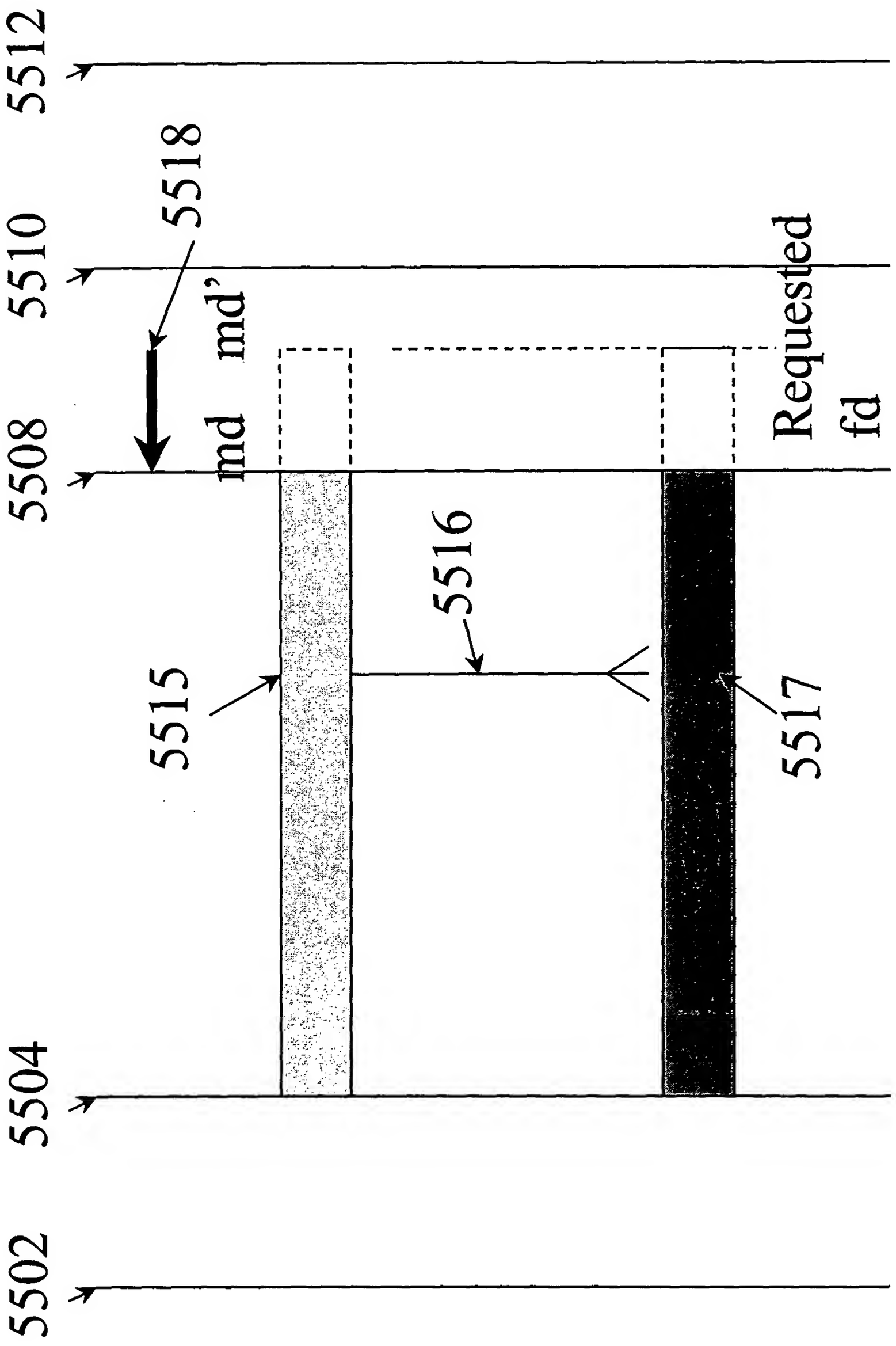

5512
5510
5518
md' mod
Requested
fd
5508
5516
5515
5517
5504
5502

FIG. 55

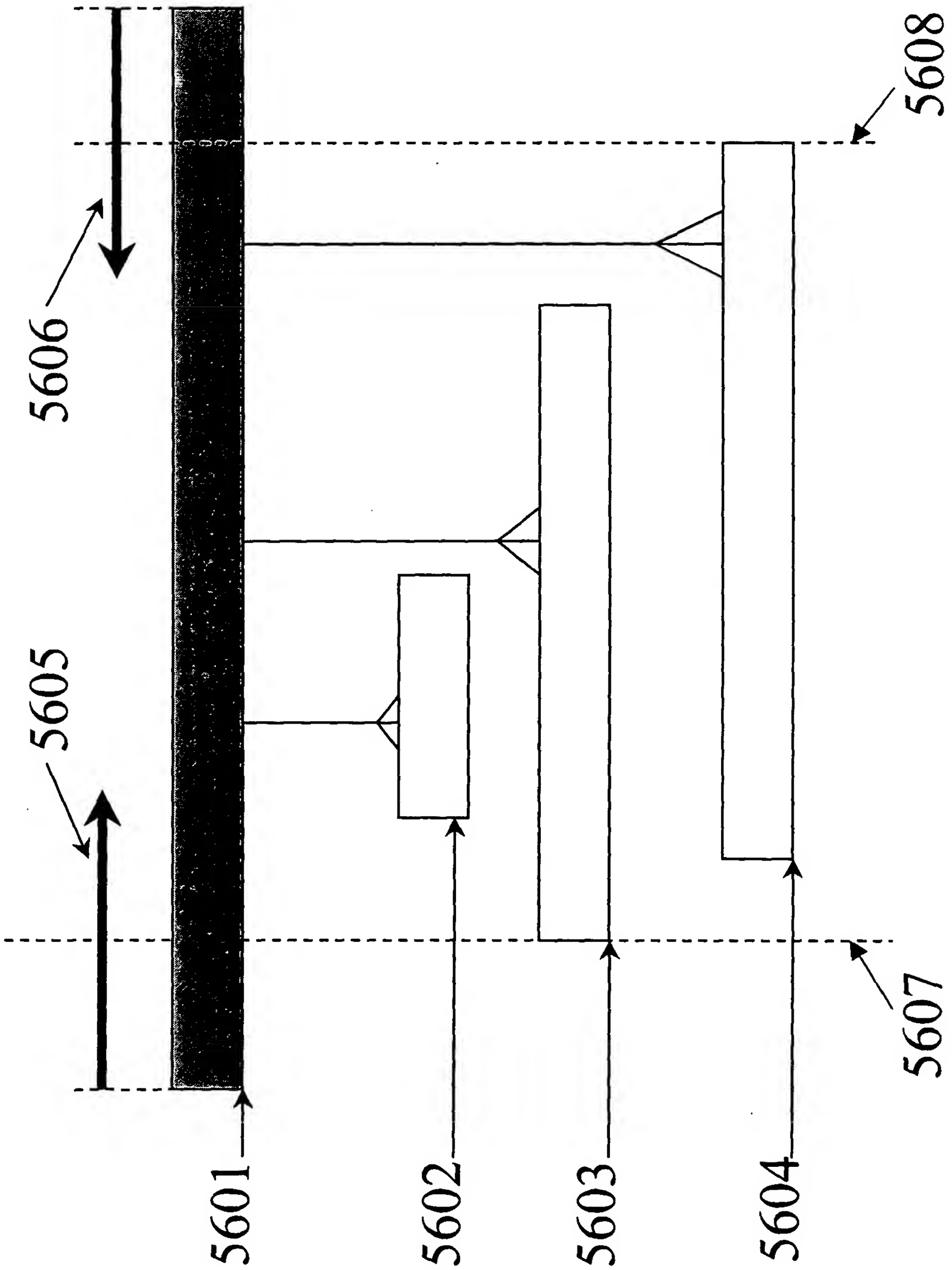


FIG. 56

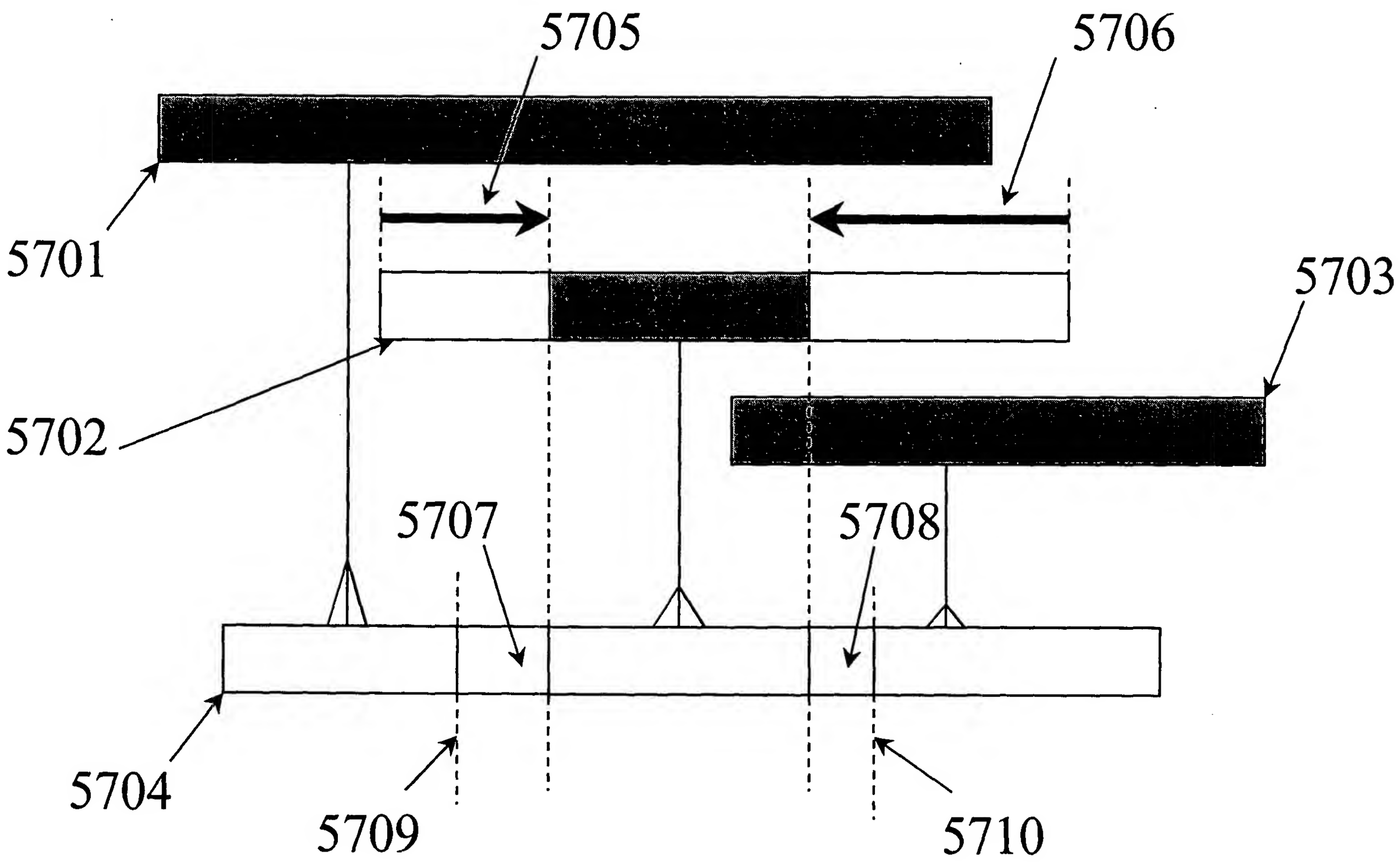


FIG. 57

If Rule on foreign key attribute on focus entity = cascade then
  Actual ui = ui (e.g. Figure 22a).
  Actual fi -> Actual ui (e.g. Figure 22a).
end if

If Rule on foreign key attribute on focus entity = bounded cascade then
Actual ui -> ui' (e.g. Figure 22b) which is not allowed as this would effectively change ui therefore the action is not allowed by the system.
Focus entity NOT inserted or alter inserted.
end if

If Rule on foreign key attribute on focus entity = restrict then
Actual ui -> ui' (e.g. Figure 22c) which is not allowed as this would effectively change ui therefore the action is not allowed by the system.
Focus entity NOT inserted or alter inserted.
end if

If Rule on foreign key attribute on focus entity = Defaults then
Only applies to transferable optional and transferable mandatory foreign keys.
Actual ui = ui (e.g. Figure 22d).
Actual fi = Requested fi.
Focus entity connected to default upstream entity from Requested fi to ui.
Focus entity connected to upstream entity from ui.
end if

If Rule on foreign key attribute on focus entity = Nullifies then
Only applies to transferable optional foreign keys.
Actual ui = ui (e.g. Figure 22e).
Actual fi = Requested fi.
Focus entity connected to null from Requested fi to ui.
Focus entity connected to upstream entity from ui.
end if

FIG. 58a

If Rule on foreign key attribute on focus entity = cascade then
Actual mi = mi.
Actual fi -> Actual mi.
end if

If Rule on foreign key attribute on focus entity = bounded cascade then
Actual mi -> mi' which is not allowed as this would effectively change mi therefore the action is not allowed by the system.
Focus entity NOT inserted or alter inserted.
end if

If Rule on foreign key attribute on focus entity = restrict then
Actual mi -> mi' as which is not allowed as this would effectively change mi therefore the action is not allowed by the system.
Focus entity NOT inserted or alter inserted.
end if

If Rule on foreign key attribute on focus entity = Defaults then
Only applies to transferable optional and transferable mandatory foreign keys as all master relations are by inspection non transferable then this case is not applicable.
end if

If Rule on foreign key attribute on focus entity = Nullifies then
Only applies to transferable optional foreign keys as all master relations are by inspection non transferable then this case is not applicable.
end if

FIG. 58b

If Rule on foreign key attribute on focus entity = cascade then
Actual ud = ud.
Actual fd -> Actual ud.
end if

If Rule on foreign key attribute on focus entity = bounded cascade then
Actual ud -> ud' which is not allowed as this would effectively change ud therefore the action is not allowed by the system.
Focus entity NOT alter deleted.
end if

If Rule on foreign key attribute on focus entity = restrict then
Actual ud -> ud' which is not allowed as this would effectively change ud therefore the action is not allowed by the system.
Focus entity NOT alter deleted.
end if

If Rule on foreign key attribute on focus entity = Defaults then
Only applies to transferable optional and transferable mandatory foreign keys.
Actual ud = ud.
Actual fd = Requested fd.
Focus entity connected to default upstream entity from ud to requested fd.
Focus entity connected to upstream entity upto ud.
end if

If Rule on foreign key attribute on focus entity = Nullifies then
Only applies to transferable optional foreign keys.
Actual ud = ud.
Actual fd = Requested fd.
Focus entity connected to null from ud to Requested fd.
Focus entity connected to upstream entity from upto ud.
end if

FIG. 58c

If Rule on foreign key attribute on focus entity = cascade then
Actual md = md.
Actual fd -> Actual md.
end if

If Rule on foreign key attribute on focus entity = bounded cascade then
Actual md -> md' which is not allowed as this would effectively change md therefore the action is not allowed by the system.
Focus entity NOT alter deleted.
end if

If Rule on foreign key attribute on focus entity = restrict then
Actual md -> md' as which is not allowed as this would effectively change md therefore the action is not allowed by the system.
Focus entity NOT alter deleted.
end if

If Rule on foreign key attribute on focus entity = Defaults then
Only applies to transferable optional and transferable mandatory foreign keys. As all master relations are by inspection non transferable then this case is not applicable.
end if

If Rule on foreign key attribute on focus entity = Nullifies then
Only applies to transferable optional foreign keys. As all master relations are by inspection non transferable then this case is not applicable.
end if

FIG. 58d

Action occurs on a row in a Focus Entity:

Refer to the Temporal Referential Tree to create stack of related entities i.e. all immediate upstream entities and all downstream entities.

Determine Referential Boundary Conditions using related rows in Affected Entities

Determine the order in which to process related rows.

For each row

Apply referential rules, taking into account the attribute and entity rules of the related entities as defined in the Temporal Data Dictionary

End-For

FIG. 59

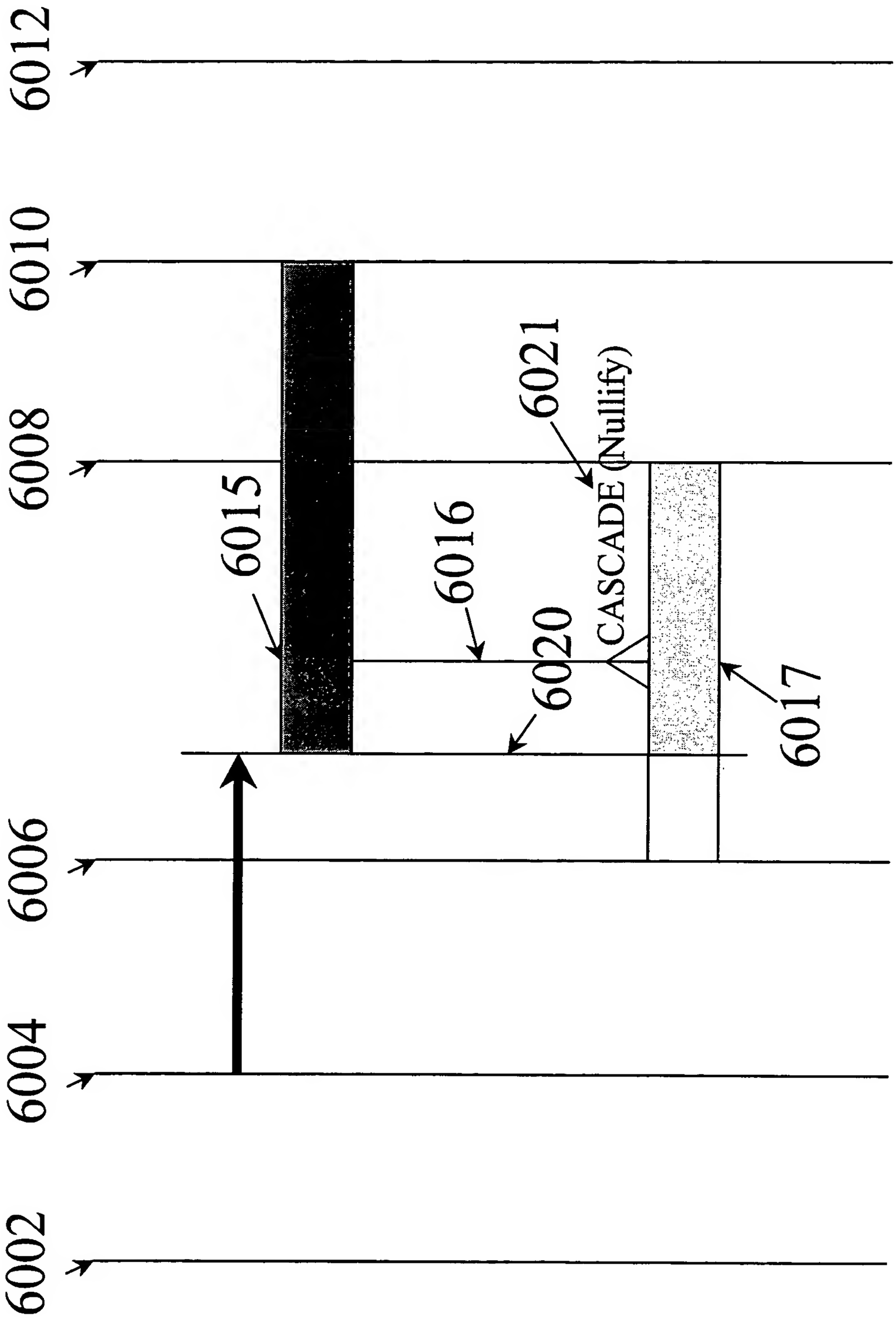

6012
6010
6008
6006
6004
6002
6015
6016
6020
6021
CASCADE (Nullify)
6017

FIG. 60

Abbreviation for Relationship Type	Description of Relationship Type	Example of focus entity	Example of related entity
dlnto	downstream lookup non transferrable optional	product	order line
dlntm	downstream lookup non transferrable mandatory	product	order line
dlto	downstream lookup transferrable optional	department	employee
dltm	downstream lookup transferrable mandatory	department	employee
ulnto	upstream lookup non transferrable optional	order line	product
ulntm	upstream lookup non transferrable mandatory	order line	product
ulto	upstream lookup transferrable optional	employee	department
ultm	upstream lookup transferrable mandatory	employee	department
mst	master (always nontransferrable nt and mandatory m)	order	na
chd	child (always nontransferrable nt and mandatory m)	order line	order

FIG. 61

Abbreviation for Rule Type	Rule Type
e	cascade (with attribution rule of extend)
b	bounded
r	restrict
d	cascade (with attribution rule of default)
n	cascade (with attribution rule of nullify)

FIG. 62

Time Points	Description
xs	start of xtime
fi	focus insert time
fd	focus delete time
di	downstream insert time
dd	downstream delete time
mi	master insert time
md	master delete time
ui	upstream insert time
ud	upstream delete time
ci	child insert time
cd	child delete time
xe	end of xtime

FIG. 63

Action	Description of Action
Insert	entity inserted with a delete time of xe
Alter Insert Back	entity insert time moved to an earlier time
Alter Insert Forward	entity insert time moved to a later time
Update	change to a primary or foreign key value
Delete	entity delete time altered from xe to an earlier time
Alter Delete Back	entity delete time altered to an earlier time
Alter Delete Forward	entity delete time altered to a later time

FIG. 64

Code	Description of Result
1	Action not allowed / breaks referential rules or entity rules / rollback
2	Action allowed / referential rules activated
3	Action allowed / no referential rules activated
4	Rule does not apply to case e.g. nullifies on master relation

FIG. 65

								RULE	TYPE								
	ACTION								dInto		dIntm		dIto		dItm		
		xs/fi			fd/xe				result	note	result	note	result	note	result	note	
	insert							e	3		3		3		3		
								b	3		3		3		3		
								r	3		3		3		3		
								d	4		4		4		4		
								n	4		4		4		4		

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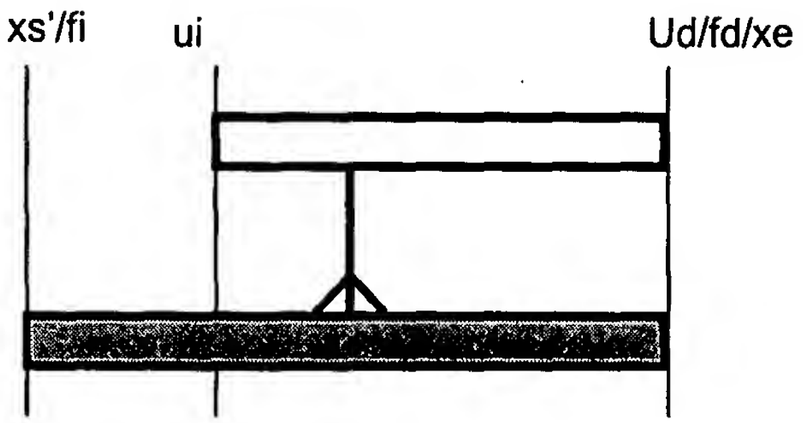
FIG. 66

									RULE	TYPE		
	ACTION									chd		
			xs/fi				fd/xe			result	note	
	insert								e	3		
									b	3		
									r	3		
									d	4		
									n	4		

FIG. 67

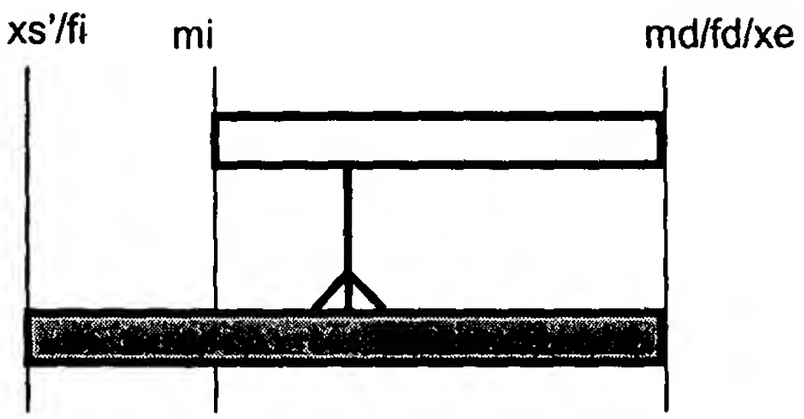


							RULE
	ACTION						
		xs/fi	ui		ud/fd/xe		
	insert						e
							b
							r
							d
							n
	insert						e
							b
							r
							d
							n

FIG. 68a

RULE	TYPE							
	ulnto		ultnm		ulto		ultm	
	result	note	result	note	result	note	result	note
e	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a
b	1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b
r	1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig22c
d	4		4		2	fi stays, fig50 and fig22d	2	fi stays, fig50 and fig22d
n	4		4		2	fi stays, fig50 and fig22e	4	
e	3	fig51	3	fig51	3	fig51	3	fig51
b	3	fig51	3	fig51	1		1	
r	3	fig51	3	fig51	1		1	
d	4		4		3	fig51	3	fig51
n	4		4		3	fig51	4	

FIG. 68b



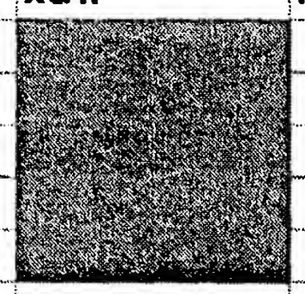
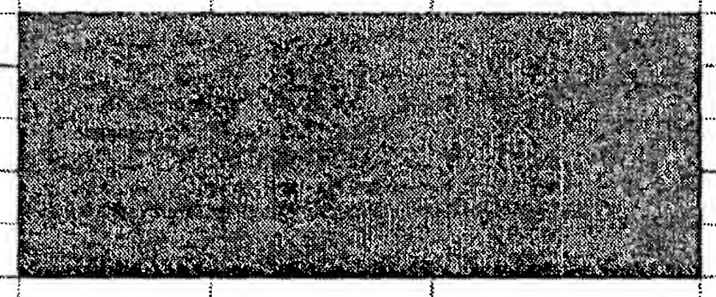
								RULE	TYPE			
									mst			
	ACTION								result	note		
			xs/fi	mi		md/fd/xe						
	insert							e	2	fi -> mi, fig50 and fig22a		
								b	1	fig50 and fig22b		
								r	1	fig50 and fig22c		
								d	4			
								n	4			
	insert							e	2	fi -> mi, fig52		
								b	1	fig52		
								r	1	fig52		
								d	4	fig52		
								n	4	fig52		

FIG. 69

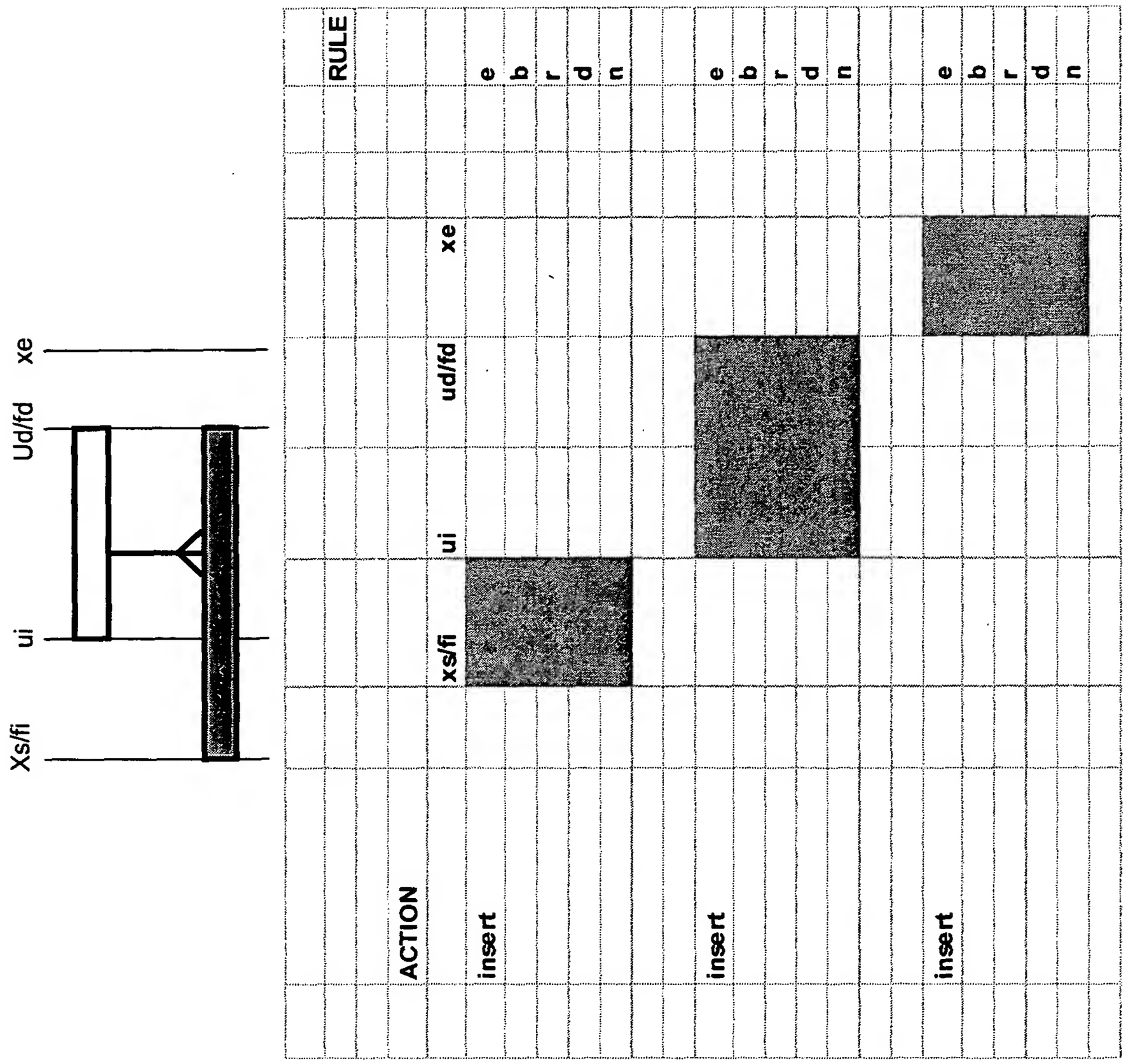

RULE
e
b
r
d
n
ACTION
insert
insert
insert
xs/fi
ui
ud/fd
xe
Xs/fi
ui
Ud/fd
xe

FIG. 70a

RULE	TYPE							
	ulnto		ulntm		ulto		ultm	
	result	note	result	note	result	note	result	note
e	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a
b	1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b
r	1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig22c
d	4		4		2	fi stays, fig50 and fig22d	2	fi stays, fig50 and fig22d
n	4		4		2	fi stays, fig50 and fig22e	4	
e	3		3		3		3	
b	3		3		1		1	
r	3		3		1		1	
d	4		4		3		3	
n	4		4		3		4	
	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rul
b	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
r	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d	4		4		1		1	
n	4		4		1		4	

FIG. 70b

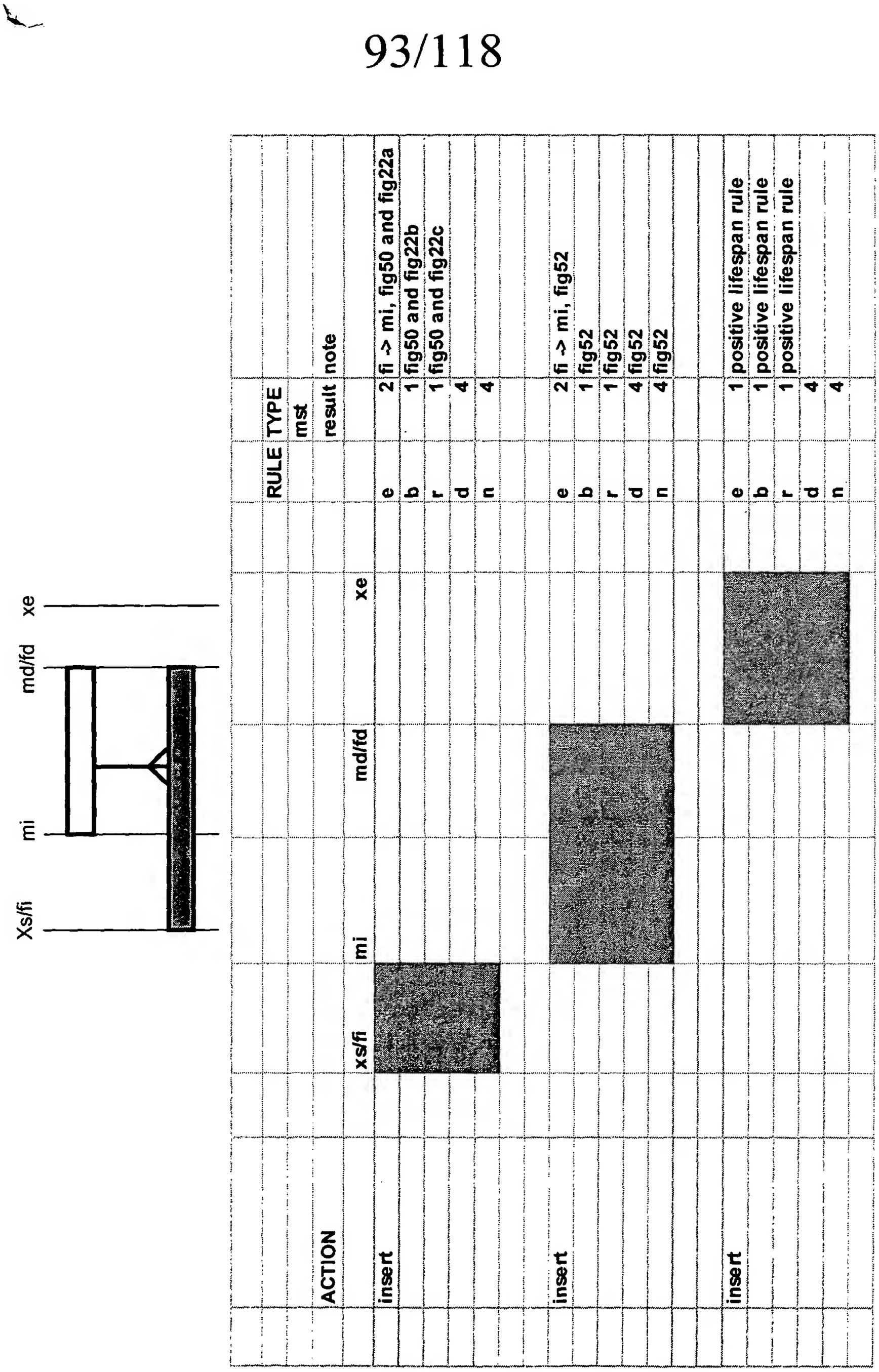

RULE TYPE
mst
result note
e 2 fi -> mi, fig50 and fig22a
b 1 fig50 and fig22b
r 1 fig50 and fig22c
d 4
n 4
e 2 fi -> mi, fig52
b 1 fig52
r 1 fig52
d 4 fig52
n 4 fig52
e 1 positive lifespan rule
b 1 positive lifespan rule
r 1 positive lifespan rule
d 4
n 4
xe
md/fd
mi
xs/fi
ACTION
insert
insert
insert
Xs/fi
mi
md/fd
xe

FIG. 71

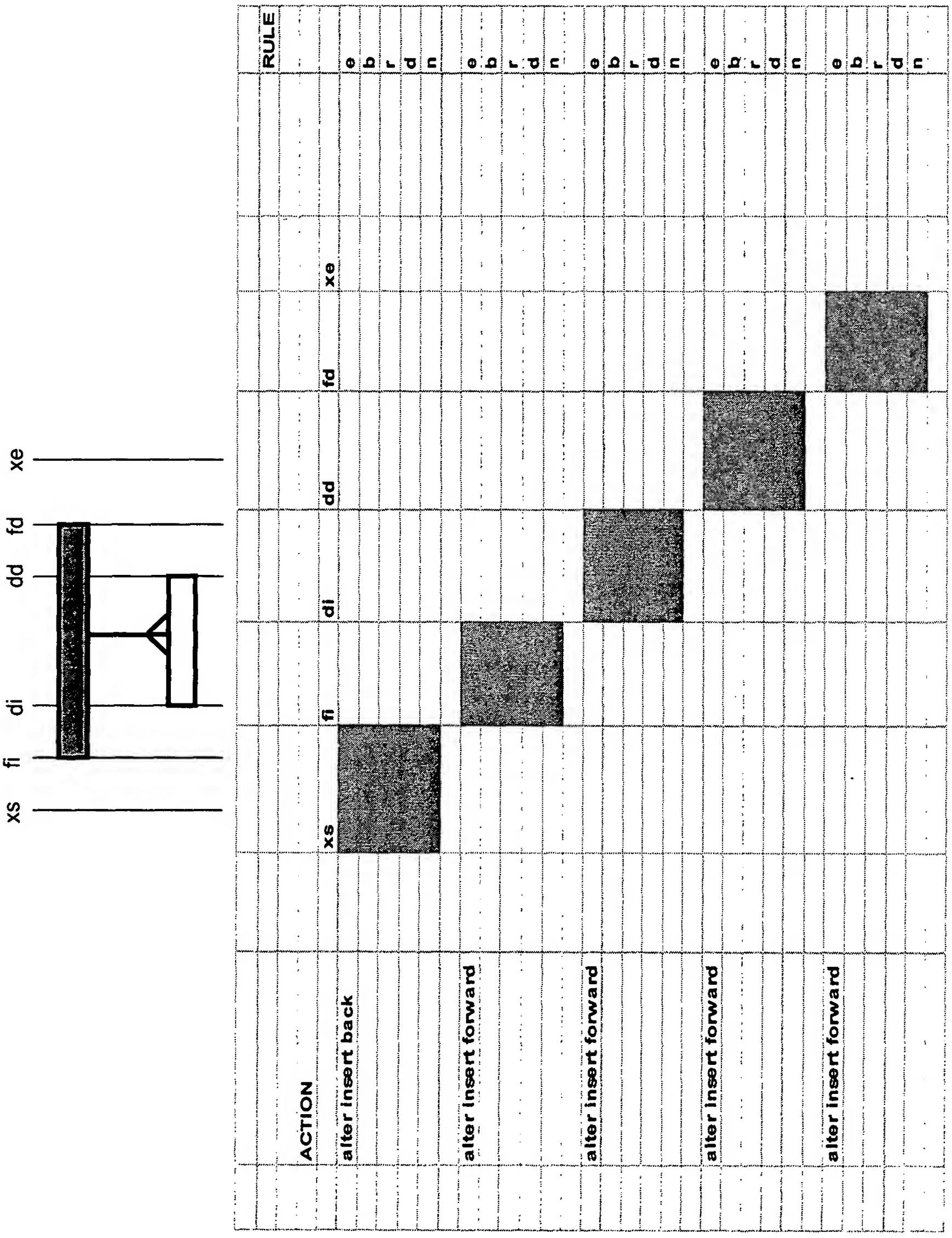
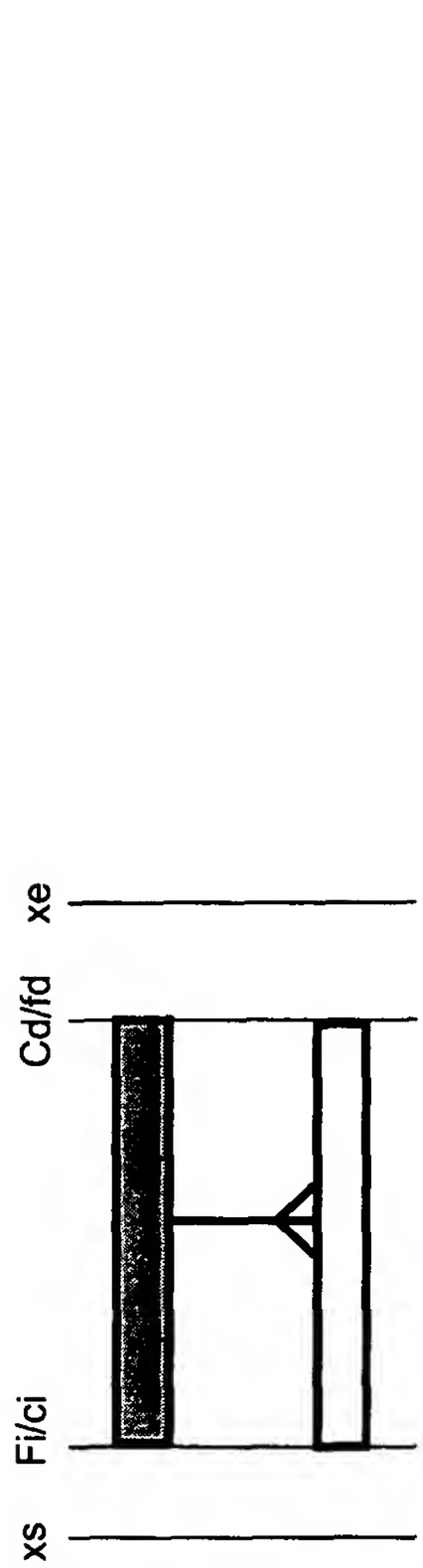

RULE
ACTION
alter insert back
alter insert forward
alter insert forward
alter insert forward
alter insert forward
xs
fi
di
dd
fd
xe

FIG. 72a

RULE	TYPE							
	dlnto		dlntm		dlto		dltm	
	result	note	result	note	result	note	result	note
e	3	fig20	3	fig20	3	fig20	3	fig20
b	3	fig20	3	fig20	3	fig20	3	fig20
r	3	fig20	3	fig20	3	fig20	3	fig20
d	4		4		3	fig20	3	fig20
n	4		4		3	fig20	4	
e	3	fig21	3	fig21	3	fig21	3	fig21
b	3	fig21	3	fig21	3	fig21	3	fig21
r	3	fig21	3	fig21	3	fig21	3	fig21
d	4		4		3	fig21	3	fig21
n	4		4		3	fig21	4	
e	2	fig22a	2	fig22a	2	fig22a	2	fig22a
b	2	fi -> di, fig22b	2	fi -> di, fig22b	2	fi -> di, fig22b	2	fi -> di, fig22b
r	2	fig22c	2	fig22c	2	fig22c	2	fig22c
d	4		4		2	fig22d	2	fig22d
n	4		4		2	fig22e	4	
e	2	disconnect or delete, fig23a	2	disconnect or delete, fig23a	2	disconnect or delete, fig23a	2	disconnect or delete, fig23a
b	2	fi -> di, fig23b	2	fi -> di, fig23b	2	fi -> di, fig23b	2	fi -> di, fig23b
r	3	fig23c	2	fig23c	2	fig23c	2	fig23c
d	2	disconnect, fig23d	2	disconnect, fig23d	2	disconnect, fig23d	2	disconnect, fig23d
n	2	disconnect, fig23e	4		2	disconnect, fig23e	4	
e	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24
b	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24
r	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24
d	4		4		1	positive lifespan rule, fig24	1	positive lifespan rule, fig24
n	4		4		1	positive lifespan rule, fig24	4	

FIG. 72b



| RULE | TYPE | chd | result | note | | |

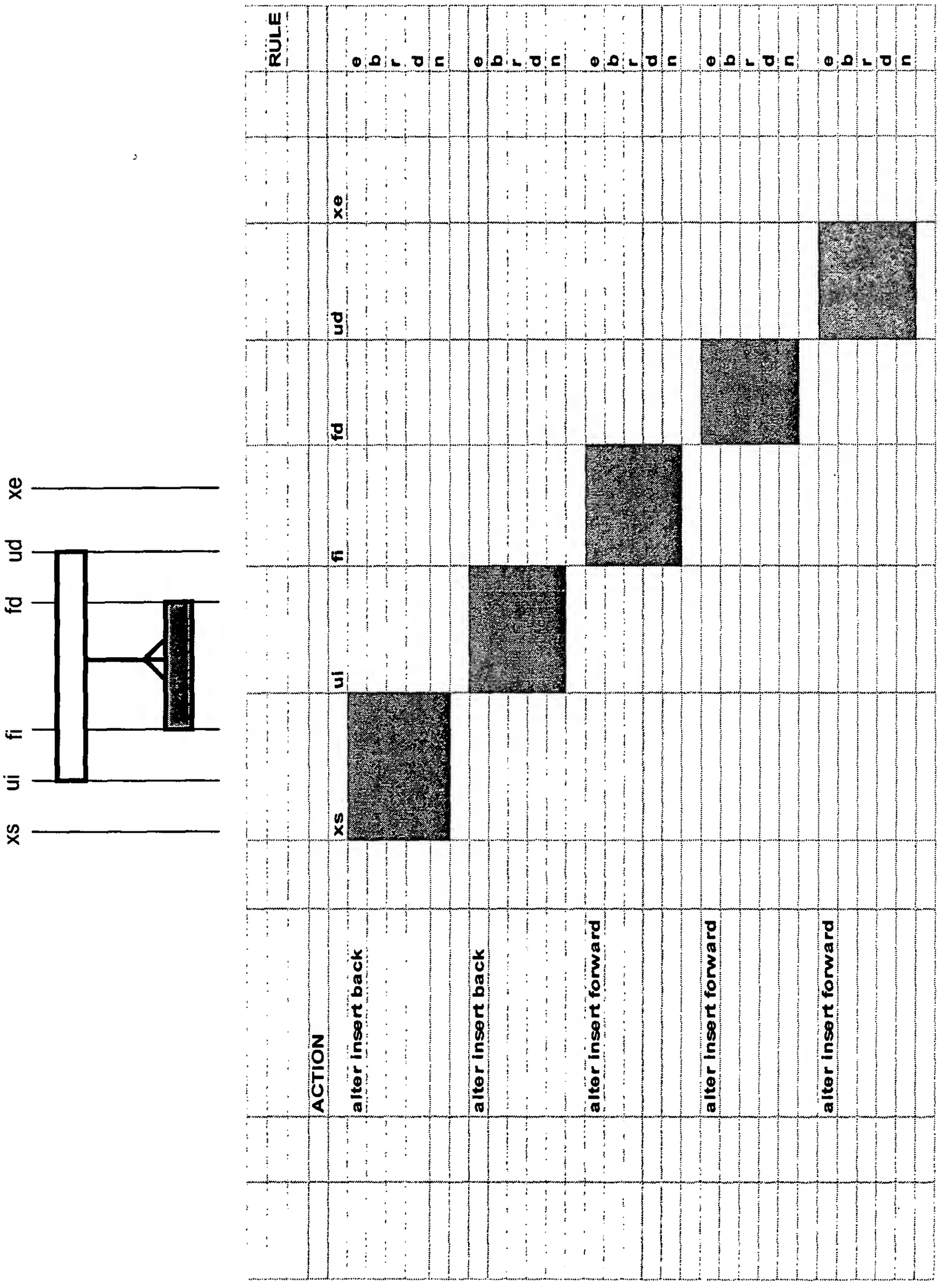

xs
ui
fi
fd
ud
xe
RULE
ACTION
alter insert back
alter insert back
alter insert forward
alter insert forward
alter insert forward

FIG. 74a

RULE		TYPE							
		uInto		uIntm		uIto		uItm	
		result	note	result	note	result	note	result	note
e		2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a
b		1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b
r		1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig22c
d		4		4		2	fi stays / disconnect, fig50 and fig22d	2	fi stays, fig50 and fig22d
n		4		4		2	fi stays / disconnect, fig50 and fig22e	4	
e		3	fig51	3	fig51	3	fig51	3	fig51
b		3	fig51	3	fig51	3	fig51	3	fig51
r		3	fig51	3	fig51	3	fig51	3	fig51
d		4		4		3	fig51	3	fig51
n		4		4		3	fig51	4	
e		3		3		3		3	
b		3		3		3		3	
r		3		3		3		3	
d		4		4		3		3	
n		4		4		3		4	
e		1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
b		1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
r		1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d		4		4		1	positive lifespan rule	1	positive lifespan rule
n		4		4		1	positive lifespan rule	4	
e		1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
b		1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
r		1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d		4		4		1	positive lifespan rule	1	positive lifespan rule
n		4		4		1	positive lifespan rule	4	

FIG. 74b

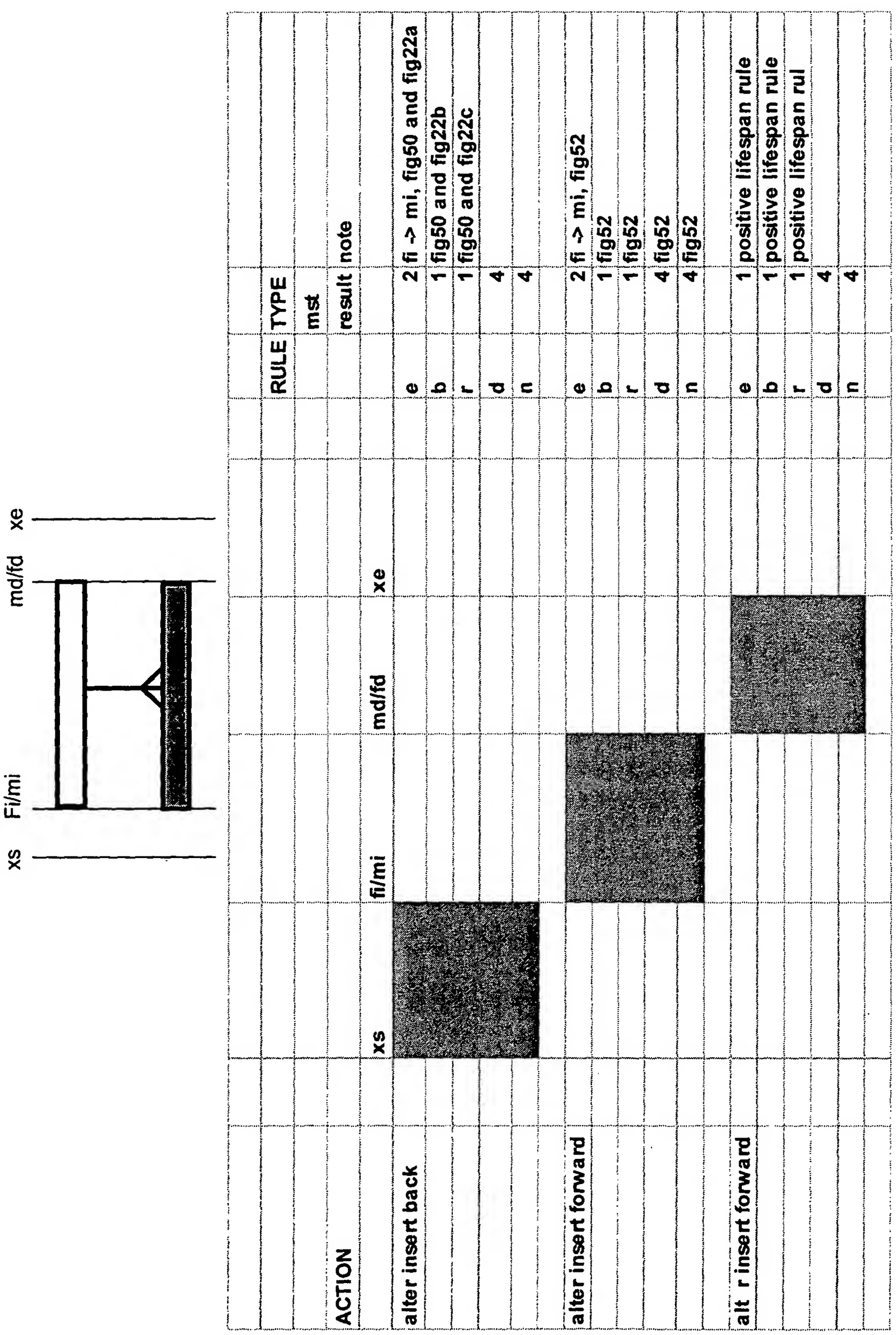

RULE TYPE
mst
result note
2 fi -> mi, fig50 and fig22a
1 fig50 and fig22b
1 fig50 and fig22c
4
4
2 fi -> mi, fig52
1 fig52
1 fig52
4 fig52
4 fig52
1 positive lifespan rule
1 positive lifespan rule
1 positive lifespan rul
4
4
e
b
r
d
n
xs
Fi/mi
md/fd
xe
fi/mi
md/fd
xe
xs
ACTION
alter insert back
alter insert forward
alt r insert forward

FIG. 75

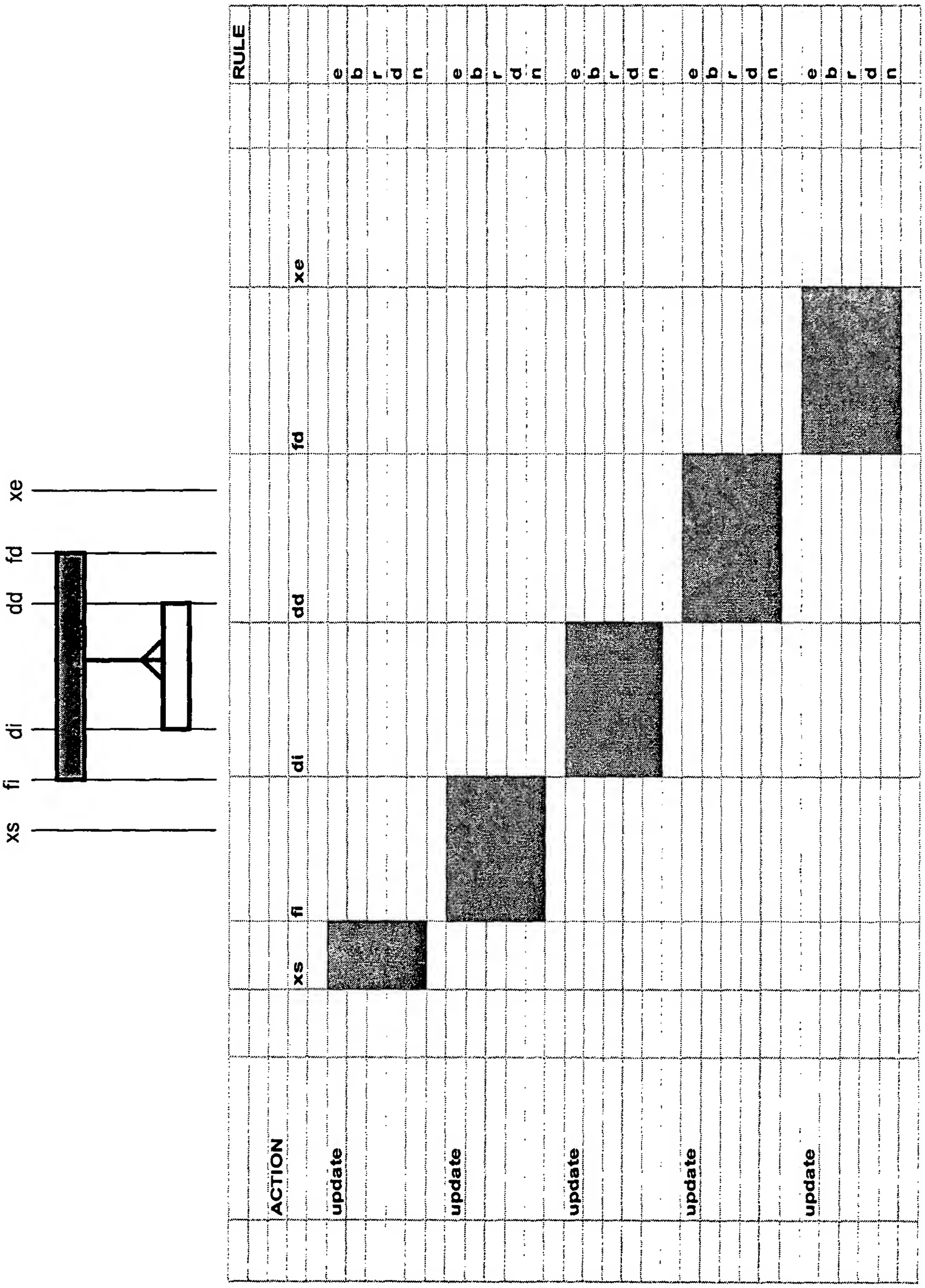

RULE
xe
xs
fi
di
dd
fd
xe
ACTION
update
update
update
update
update

FIG. 76a

CASE1										
	RULE	TYPE								
		dInto		dIntm		dIto		dItm		
		result	note	result	note	result	note	result	note	
	e	4		4		4		4		
	b	4		4		4		4		
	r	4		4		4		4		
	d	4		4		4		4		
	n	4		4		4		4		
	e	3		3		3		3		
	b	3		3		3		3		
	r	3		3		3		3		
	d	3		3		3		3		
	n	3		3		3		3		
	e	3		3		3		3		
	b	3		3		3		3		
	r	3		3		3		3		
	d	3		3		3		3		
	n	3		3		3		3		
	e	3		3		3		3		
	b	3		3		3		3		
	r	3		3		3		3		
	d	3		3		3		3		
	n	3		3		3		3		
	e	4		4		4		4		
	b	4		4		4		4		
	r	4		4		4		4		
	d	4		4		4		4		
	n	4		4		4		4		

FIG. 76b

CASE 2										
	RULE	TYPE								
		dInto		dIntm		dIto		dItm		
		result	note	result	note	result	note	result	note	
	e	4		4		4		4		
	b	4		4		4		4		
	r	4		4		4		4		
	d	4		4		4		4		
	n	4		4		4		4		
	e	1		1		1		1		
	b	1		1		1		1		
	r	1		1		1		1		
	d	1		1		1		1		
	n	1		1		1		1		
	e	1		1		1		1		
	b	1		1		1		1		
	r	1		1		1		1		
	d	1		1		1		1		
	n	1		1		1		1		
								1		
	e	1		1		1		1		
	b	1		1		1		1		
	r	1		1		1		1		
	d	1		1		1		1		
	n	1		1		1		1		
	e	4		4		4		4		
	b	4		4		4		4		
	r	4		4		4		4		
	d	4		4		4		4		
	n	4		4		4		4		

FIG. 76c

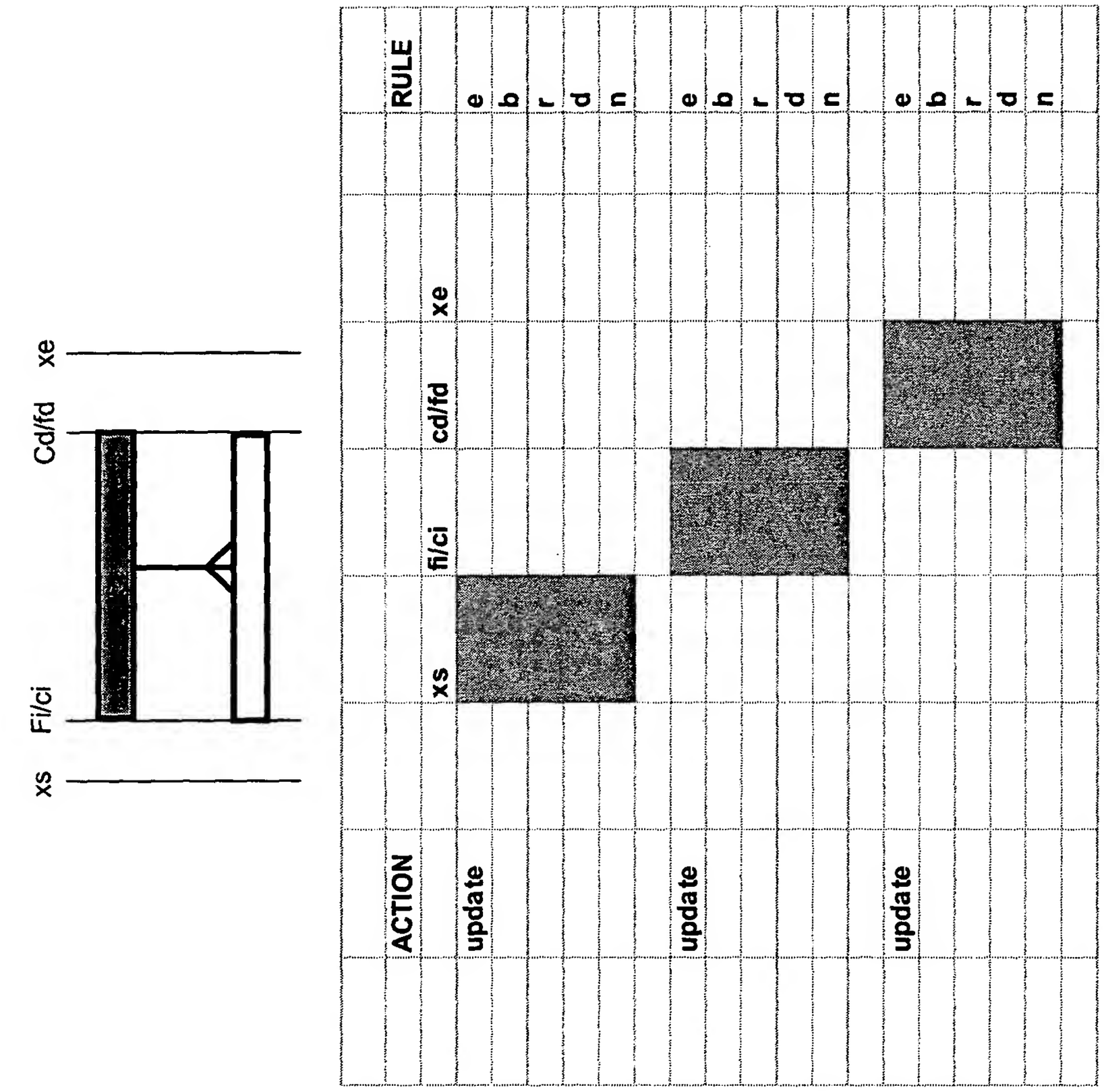

RULE
ACTION
update
update
update
xs
fi/ci
cd/fd
xe
xs
Fi/ci
Cd/fd
xe

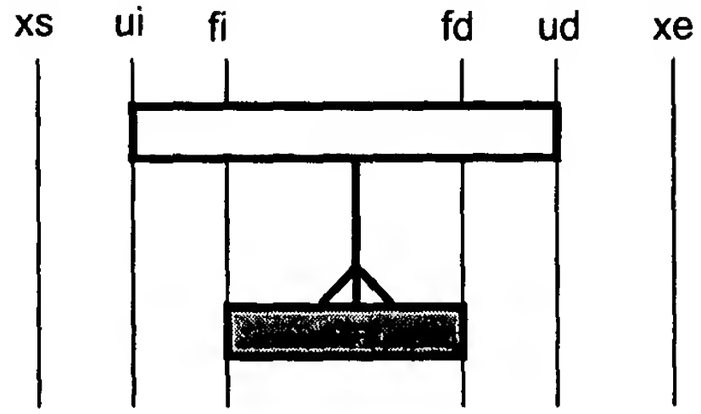
FIG. 77a

CASE 1				
	RULE	TYPE		
		chd		
		result	note	
	e	4		
	b	4		
	r	4		
	d	4		
	n	4		
	e	3		
	b	3		
	r	3		
	d	3		
	n	3		
	e	4		
	b	4		
	r	4		
	d	4		
	n	4		

FIG. 77b

CASE 2				
	RULE	TYPE		
		chd		
		result	note	
	e	4		
	b	4		
	r	4		
	d	4		
	n	4		
	e	1		
	b	1		
	r	1		
	d	1		
	n	1		
	e	4		
	b	4		
	r	4		
	d	4		
	n	4		

FIG. 77c

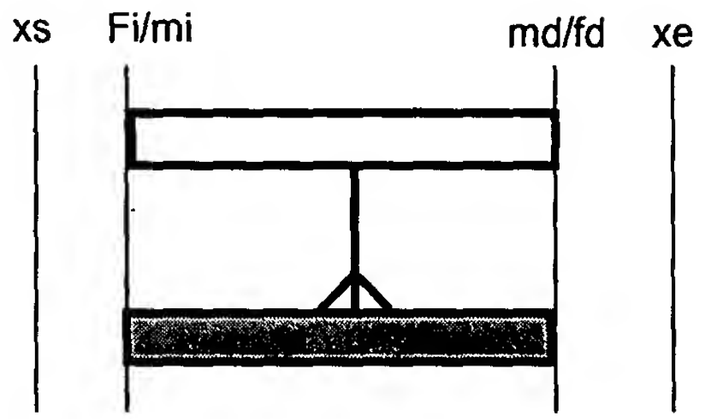


ACTION	xs	ui	fi	fd	ud	xe	RULE
update							e b r d n
update							e b r d n
update							e b r d n
update							e b r d n
update							e b r d n

FIG. 78a

	TYPE								
RULE	uinto		uintm		ulto		ultm		
	result	note	result	note	result	note	result	note	
e	4		4						
b	4		4						
r	4		4		see fig 70a and 70b		see fig 70a and 70b		
d	4		4		for ulto, ultm		for ulto, ultm		
n	4		4						
e	4		4						
b	4		4						
r	4		4		see fig 70a and 70b		see fig 70a and 70b		
d	4		4		for ulto, ultm		for ulto, ultm		
n	4		4						
e	4		4						
b	4		4						
r	4		4		see fig 70a and 70b		see fig 70a and 70b		
d	4		4		for ulto, ultm		for ulto, ultm		
n	4		4						
e	4		4						
b	4		4						
r	4		4		see fig 70a and 70b		see fig 70a and 70b		
d	4		4		for ulto, ultm		for ulto, ultm		
n	4		4						
e	4		4						
b	4		4						
r	4		4		see fig 70a and 70b		see fig 70a and 70b		
d	4		4		for ulto, ultm		for ulto, ultm		
n	4		4						

FIG. 78b



ACTION					RULE	TYPE		
	xs	fi/mi	md/fd	xe		mst		
						result	note	
update					e	4		
					b	4		
					r	4		
					d	4		
					n	4		
update					e	1		
					b	1		
					r	1		
					d	1		
					n	1		
update					e	4		
					b	4		
					r	4		
					d	4		
					n	4		

FIG. 79

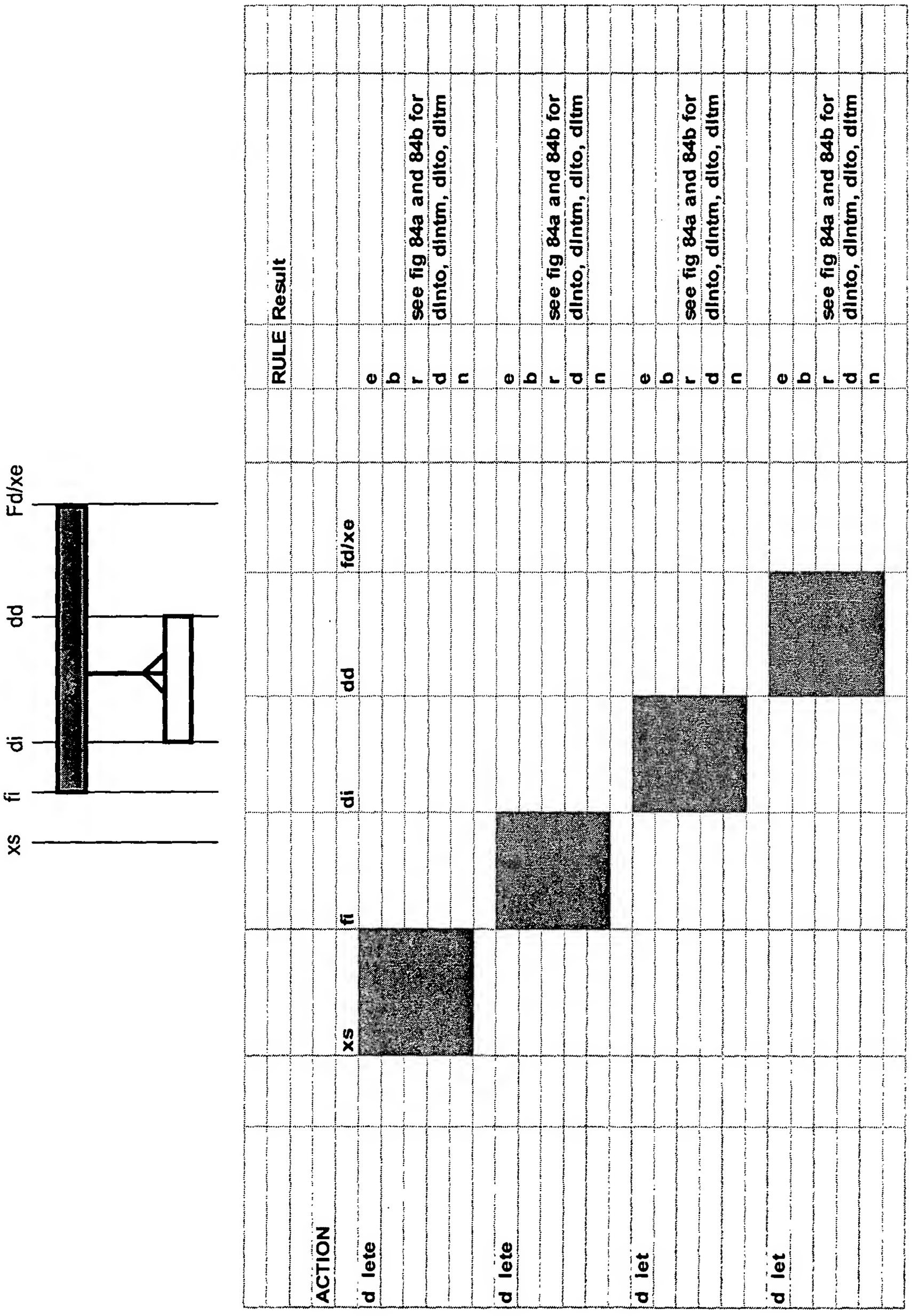
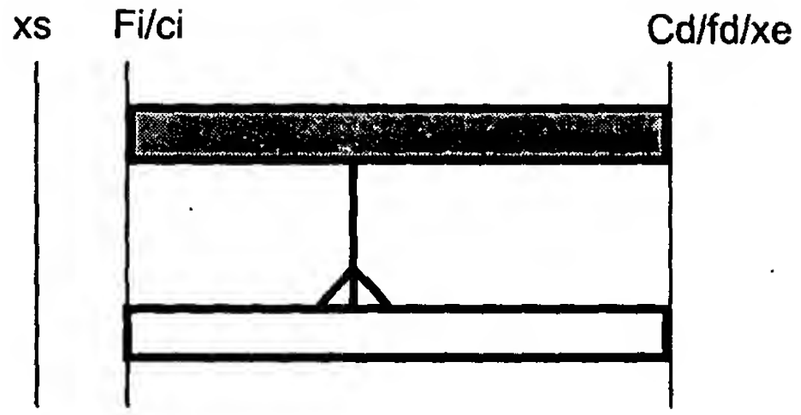
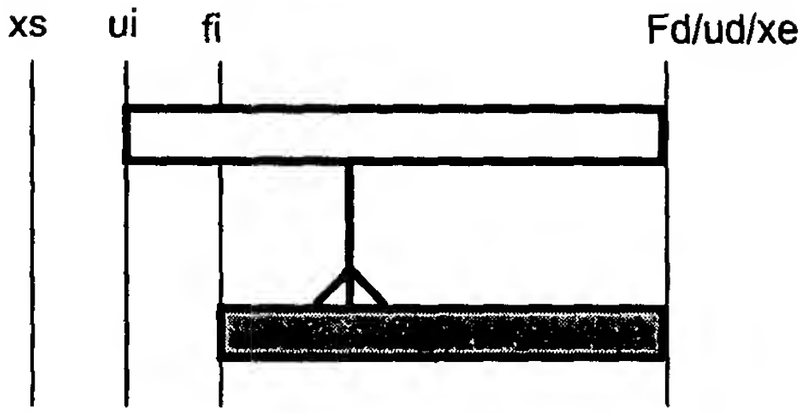

xs
fi
di
dd
Fd/xe
ACTION
RULE
RULE Result
fd/xe
delete
delete
delete
delete
see fig 84a and 84b for dlnto, dlntm, dlto, dltm
see fig 84a and 84b for dlnto, dlntm, dlto, dltm
see fig 84a and 84b for dlnto, dlntm, dlto, dltm
see fig 84a and 84b for dlnto, dlntm, dlto, dltm

FIG. 80



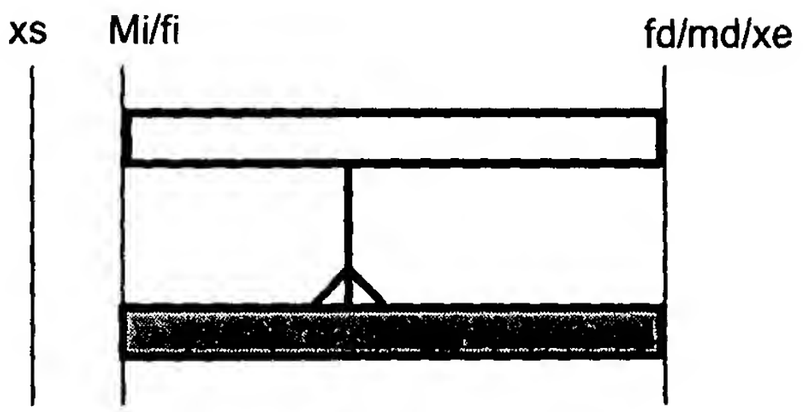
								RULE	Result	
	ACTION									
			xs	fi/ci	cd/fd/xe					
	delete							e		
								b		
								r	see fig 85	
								d	for chd	
								n		
	delete							e		
								b		
								r	see fig 85	
								d	for chd	
								n		

FIG. 81



							RULE	Result
ACTION								
		xs	ui	fi	fd/ud/xe			
delete							e	
							b	
							r	see fig 86a and 86b for
							d	ulnto, ulntm, ulto, ultm
							n	
delete							e	
							b	see fig 86a and 86b for
							r	ulnto, ulntm, ulto, ultm
							d	
							n	
delete							e	
							b	see fig 86a and 86b for
							r	ulnto, ulntm, ulto, ultm
							d	
							n	

FIG. 82



						RULE	Result
ACTION							
		xs	fi/mi	md/fd/xe			
delete						e	
						b	
						r	see fig 87
						d	for mst
						n	
delete						e	
						b	see fig 87
						r	for mst
						d	
						n	

FIG. 83

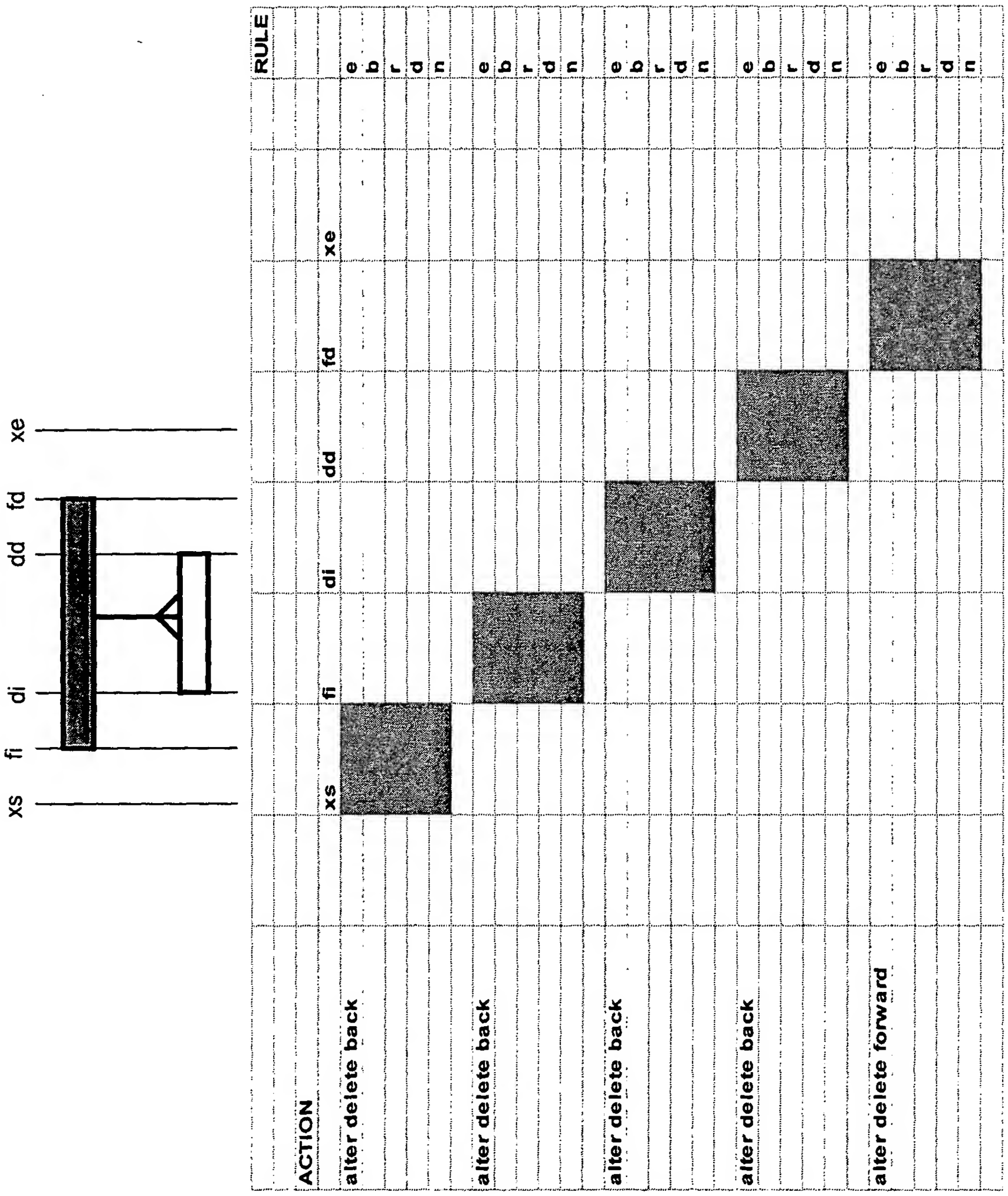
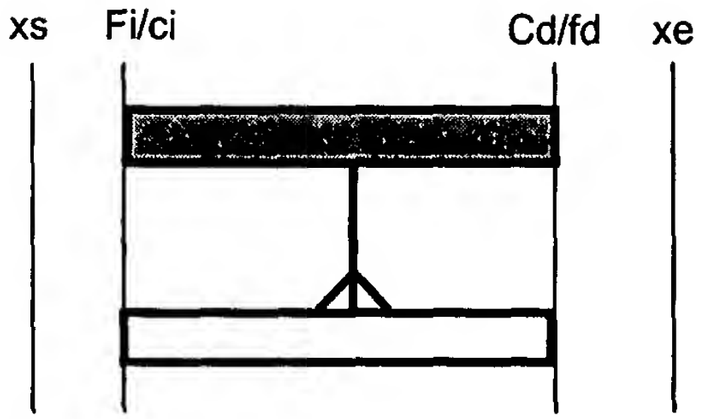

RULE
e b r d n
ACTION
alter delete back
alter delete back
alter delete back
alter delete back
alter delete forward
xs fi di dd fd xe
xs fi di dd fd xe

FIG. 84a

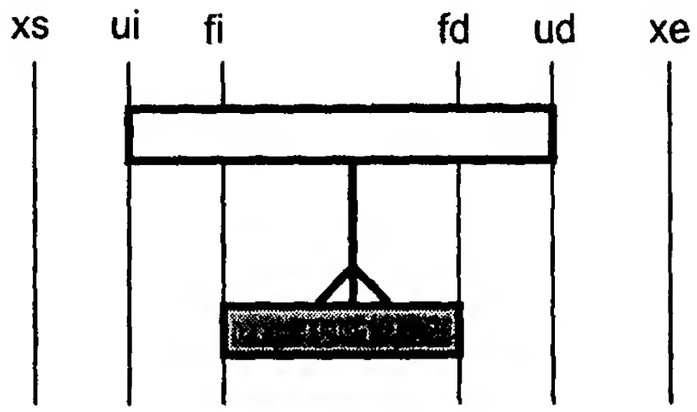
RULE	TYPE							
	dInto		dIntm		dIto		dItm	
	result	note	result	note	result	note	result	note
e	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rul
b	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rul
r	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d	4		4		1	positive lifespan rule	1	positive lifespan rul
n	4		4		1	positive lifespan rule	4	
	2	disconnect or delete	2	disconnect or delete	2	disconnect or delete	2	disconnect or delete
b	2	fd -> dd	2	fd -> dd	2	fd -> dd	2	fd -> dd
r	3		2		2		2	
d	2	disconnect	2	disconnect	2	disconnect	2	disconnect
n	2	disconnect	4		2	disconnect	4	
	2		2		2		2	
b	2	fd -> dd	2	fd -> dd	2	fd -> dd	2	fd -> dd
r	2		2		2		2	
d	4		4		2		2	
n	4		4		4		4	
e	3		3		3		3	
b	3		3		3		3	
r	3		3		3		3	
d	4		4		3		3	
n	4		4		3		4	
e	3		3		3		3	
b	3		3		3		3	
r	3		3		3		3	
d	4		4		3		3	
n	4		4		3		4	

FIG. 84b



								RULE	TYPE		
									chd		
	ACTION								result	note	
			xs	fi/ci	cd/fd	xe					
	alter delete back							e	1	positive lifespan rule	
								b	1	positive lifespan rule	
								r	1	positive lifespan rule	
								d	4		
								n	4		
	alter delete back							e	2		
								b	2	fd ->cd	
								r	2		
								d	4		
								n	4		
	alter delete forward							e	3		
								b	3		
								r	3		
								d	4		
								n	4		

FIG. 85

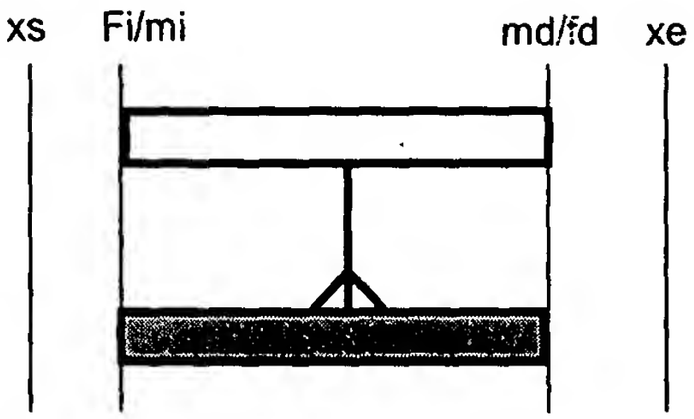


									RULE
ACTION									
		xs	ui	fi	fd	ud	xe		
alter delete back									e
									b
									r
									d
									n
alter delete back									e
									b
									r
									d
									n
alter delete back									e
									b
									r
									d
									n
alter delete back									e
									b
									r
									d
									n
alter delete forward									e
									b
									r
									d
									n

FIG. 86a

RULE	TYPE							
	ulnto		ulntm		ulto		ultm	
	result	note	result	note	result	note	result	note
e	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
b	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
r	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d	4		4		1	positive lifespan rule	1	positive lifespan rule
n	4		4		1	positive lifespan rule	4	
e	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
b	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
r	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d	4		4		1	positive lifespan rule	1	positive lifespan rule
n	4		4		1	positive lifespan rule	4	
	3		3		3		3	
b	3		3		3		3	
r	3		3		3		3	
d	4		4		3		3	
n	4		4		3		4	
e	3	fig 54	3	fig 54	3	fig 54	3	fig 54
b	3	fig 54	3	fig 54	3	fig 54	3	fig 54
r	3	fig 54	3	fig 54	3	fig 54	3	fig 54
d	4		4		3	fig 54	3	fig 54
n	4		4		3	fig 54	4	
e	2	fd -> ud, fig 53	2	fd -> ud, fig 53	2	fd -> ud, fig 53	2	fd -> ud, fig 53
b	1	fig53	1	fig53	1	fig53	1	fig53
r	1	fig53	1	fig53	1	fig53	1	
d	4		4		2	fd stays / disconnect, fig53	2	fd stays / disconnect, fig53
n	4		4		2	fd stays / disconnect, fig53	4	

FIG. 86b



							RULE	TYPE	
ACTION								mst	
								result	note
		xs	fi/mi	md/fd	xe				
alter delete back							e	1	positive lifespan rule
							b	1	positive lifespan rule
							r	1	positive lifespan rule
							d	4	
							n	4	
alter delete back							e	1	fig55
							b	1	fig55
							r	1	fig55
							d	4	fig55
							n	4	fig55
alter delete forward							e	2	fd -> md, fig53
							b	1	fig53
							r	1	fig53
							d	4	
							n	4	

FIG. 87